Ethane, 1,1,1-trichloro-: Environment tier II assessment

22 November 2013

CAS Registry Number: 71-55-6.

Preface

This assessment was carried out by staff of the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) using the Inventory Multi-tiered Assessment and Prioritisation (IMAP) framework.

The IMAP framework addresses the human health and environmental impacts of previously unassessed industrial chemicals listed on the Australian Inventory of Chemical Substances (the Inventory).

The framework was developed with significant input from stakeholders and provides a more rapid, flexible and transparent approach for the assessment of chemicals listed on the Inventory.

Stage One of the implementation of this framework, which lasted four years from 1 July 2012, examined 3000 chemicals meeting characteristics identified by stakeholders as needing priority assessment. This included chemicals for which NICNAS already held exposure information, chemicals identified as a concern or for which regulatory action had been taken overseas, and chemicals detected in international studies analysing chemicals present in babies' umbilical cord blood.

Stage Two of IMAP began in July 2016. We are continuing to assess chemicals on the Inventory, including chemicals identified as a concern for which action has been taken overseas and chemicals that can be rapidly identified and assessed by using Stage One information. We are also continuing to publish information for chemicals on the Inventory that pose a low risk to human health or the environment or both. This work provides efficiencies and enables us to identify higher risk chemicals requiring assessment.

The IMAP framework is a science and risk-based model designed to align the assessment effort with the human health and environmental impacts of chemicals. It has three tiers of assessment, with the assessment effort increasing with each tier. The Tier I assessment is a high throughput approach using tabulated electronic data. The Tier II assessment is an evaluation of risk on a substance-by-substance or chemical category-by-category basis. Tier III assessments are conducted to address specific concerns that could not be resolved during the Tier II assessment.

These assessments are carried out by staff employed by the Australian Government Department of Health and the Australian Government Department of the Environment and Energy. The human health and environment risk assessments are conducted and published separately, using information available at the time, and may be undertaken at different tiers.

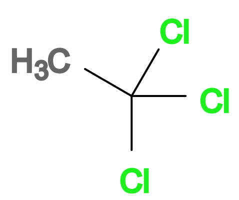
This chemical or group of chemicals are being assessed at Tier II because the Tier I assessment indicated that it needed further investigation.

For more detail on this program please visit: www.nicnas.gov.au.

Disclaimer

Acronyms & Abbreviations

Chemical Identity

Synonyms	1,1,1-Trichloroethane 1,1,1-TCE Methyl chloroform
Structural Formula	
Molecular Formula	$C_2H_3Cl_3$

Molecular Weight (g/mol)	133.41
SMILES	C(C)(Cl)(Cl)Cl

Physical and Chemical Properties

The physical and chemical property data for this chemical were retrieved from the databases included in the OECD QSAR Toolbox (LMC, 2013).

Physical Form	Liquid
Melting Point	-30.4ºC (exp.)
Boiling Point	74ºC (exp.)
Vapour Pressure	16 532 Pa (exp.)
Water Solubility	1290 mg/L (exp.)
Ionisable in the Environment?	No
log K_{ow}	2.49 (exp.)

Import, Manufacture and Use

Australia

Ethane, 1,1,1-trichloro- (or 1,1,1-trichloroethane) is an ozone depleting substance. Ozone depleting substances are controlled under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* (the Ozone Act) (Cwlth) in Australia.

Under the Ozone Act, bulk imports of the chemical are banned, unless it is for use as a feedstock. Additionally, the import, manufacture and use of any volume of the chemical (except for use as a feedstock) are prohibited by the Ozone Act. However, a licence may be obtained to gain an exemption from these requirements (Australian Government Department of the Environment, 2013a; Commonwealth of Australia, 1989).

Licences may only allow imports of the chemical for uses in accordance with Annex IV of the Seventh Meeting of the Parties to the *Montreal Protocol on Substances that Deplete the Ozone Layer* (the Montreal Protocol). Uses listed under Annex IV include use in research and development, analytical uses and regulated applications (for example, quality control), and laboratory use (Australian Government Department of the Environment, 2013b; UNEP, 1995). No licences have been issued allowing the import of the chemical for this purpose in the last 10 years.

The quantity of the chemical that is imported or manufactured for use as a feedstock must be reported to the Australian Government Department of the Environment on a quarterly basis (Commonwealth of Australia, 1989). There have been no reported imports of the chemical as a feedstock in the last 10 years.

International

In 2007, approximately 78 000 tonnes of 1,1,1-trichloroethane were produced in the USA. More than 98% of this volume was used as a chemical feedstock, notably in the production of hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs) (OECD, 2009).

The chemical is registered under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) legislation for use as a closed-system industrial intermediate in the European Union (ECHA, 2013).

Under the Montreal Protocol, production and consumption of the chemical were phased out in developed countries of the United Nations (UN) by 1 January 1996. The phase-out in developing countries of the UN will be complete by 1 January 2015 (UNEP, 2012).

Historically, 1,1,1-trichloroethane was used globally as a solvent in a wide variety of consumer and industrial products including adhesives, paints, varnishes, inks, pesticides, aerosols, dry cleaning agents and typewriter correction fluids. The chemical was also used for metal degreasing, cleaning plastic moulds, and in post-harvest fumigation (IPCS, 1992). These emissive uses have been effectively phased out since the Montreal Protocol entered into force in 1989.

Environmental Regulatory Status

Australia

1,1,1-Trichloroethane is a scheduled substance under the Ozone Act. The Act gives effect to Australia's obligations under the Montreal Protocolby controlling the manufacture, import and export of ozone depleting substances and listing banned applications. Import or manufacture of the chemical is banned, and it can only be used if an exemption licence is obtained from the Australian Government Department of the Environment, or it is used as a feedstock (Commonwealth of Australia, 1989).

United Nations

The chemical is one of the controlled substances listed under Annex B of the Montreal Protocol (UNEP, 2000). The Montreal Protocol calls for the phase-out of use of the chemical. All 197 countries of the UN have ratified the Montreal Protocol, including Australia, and only a few countries are yet to ratify the last amendment to the Montreal Protocol (UNEP, 2013).

OECD

The chemical was sponsored by the United States for assessment under the 28th Screening Information Dataset (SIDS) Initial Assessment Meeting (SIAM 28) in 2009. The SIDS Initial Assessment Profile (SIAP) found that the chemical may present a hazard to human health and the environment (OECD, 2009).

Canada

The chemical is listed on Schedule 1 of the *Canadian Environmental Protection Act 1999* (the Toxic Substances List). Use is prohibited for any purpose other than as a feedstock, as an analytical standard, or for an essential use (Environment Canada, 2013a).

The chemical has been categorised as Persistent (P), not Bioaccumulative (not B) and not Inherently Toxic to the Environment (not iT_E) by Environment Canada during the Categorization of the Domestic Substances List (DSL) (Environment Canada, 2013b).

European Union

The chemical is identified as an ozone depleting substance and is controlled under *Regulation No 1005/2009 of the European Parliament and of the Council of 16 September 2009 on Substances that Deplete the Ozone Layer*. The production, trade and use of the chemical is prohibited, unless the chemical is to be used as a feedstock, process agent, an essential laboratory or analytical use, or is destined for destruction or reclamation (European Union, 2009).

United States of America

The chemical is identified as a Class I Substance under Title VI of the *Clean Air Act 1970*. Production and use of the chemical is prohibited except for specified exceptions, including essential uses (US EPA, 2013a; 2013a).

Environmental Exposure

The Ozone Act prohibits the use of 1,1,1-trichloroethane in Australia if the use results in discharge of the chemical to the environment (Commonwealth of Australia, 1989).

Additionally, the uses of the chemical that may be allowed under the provision of a licence are generally limited to those listed under Annex IV of the Seventh Meeting of the Parties to the Montreal Protocol. These are low volume, closed system or reactive uses, such as use in research and development, analytical uses and regulated applications (for example, quality control), and laboratory use (Australian Government Department of the Environment, 2013b; UNEP, 1995).

Therefore, the chemical is not expected to be released into the environment as a result of current industrial uses in Australia.

Environmental Fate

Partitioning

The measured Henry's Law constant for partitioning of 1,1,1-trichloroethane from water into air is 1740 Pa-m^3/mol at 24°C (LMC, 2013). This large partitioning ratio indicates that the chemical is highly volatile from water and moist soil.

The volatility of the chemical from water has been confirmed in a study which showed that more than 90% of the chemical in a 1 mg/L aqueous solution of the substance evaporated within 60 to 80 minutes at 25°C (IPCS, 1992). The rate of volatilisation from solution was not significantly altered by the addition of solid phases such as clay or peat which indicates that adsorption of the chemical to sediments was not significant in this test. Another study found that 45–90% of the chemical volatilised when applied to unsaturated soils in laboratory soil leaching tests (IPCS, 1992).

A measured organic carbon normalized adsorption coefficient (K_{OC}) of 89.1 L/kg is available for the chemical (LMC, 2013). The relatively low magnitude of the water to organic carbon in soil partitioning ratio indicates that the chemical is highly mobile in soil. The potential for the chemical to leach through soil has been confirmed in soil column leaching tests on aerobic unsaturated soils, although these tests also showed that the majority of the substance was lost by volatilization (IPCS, 1992).

Calculations with a standard multimedia partitioning (fugacity) model assuming equal and continuous distributions to air, water and soil compartments (Level III approach) predict that the chemical will mainly partition to air (49%) and water (47%) compartments, with minor partitioning to soil (4%). However, with sole release to the atmosphere, the model predicts that 99.8% of the chemical will remain in the air compartment (US EPA, 2008). The latter scenario is expected to be the more likely route for release of this chemical into the environment.

The chemical is a highly volatile substance that, if released, will partition primarily into the atmosphere.

Degradation

1,1,1-Trichloroethane is not rapidly degradable in water or soil under aerobic conditions. The aerobic biodegradation of the chemical was determined as 0% after 14 days in a study conducted in accordance with OECD Test Guideline (TG) 301 C (LMC, 2013). The chemical does undergo very slow abiotic degradation in water by means of parallel hydrolysis and dehydrochlorination reactions. The measured abiotic degradation half life in water at 20°C is between 6 months and 1 year (unspecified pH) (IPCS, 1992).

There are various studies which have shown that the chemical is biodegradable under anaerobic conditions, using non-standard tests and extended durations. 1,1-Dichloroethane was a major degradant identified in several anaerobic biodegradation studies (IPCS, 1992).

The major environmental degradation processes for 1,1,1-trichloroethane involve oxidation and photolysis in the atmosphere. The chemical has relatively low reactivity towards indirect photo-oxidation by hydroxyl radicals and the lifetime with respect to reactions with hydroxyl radicals in the lower atmosphere (troposphere) is 6.1 years. It is estimated that up to 15% of the quantity of 1,1,1-trichloroethane that is released to the atmosphere is ultimately transported through the troposphere to the stratosphere. The chemical is degraded in the stratosphere by ultraviolet (UV) photolysis. The stratospheric lifetime for the chemical is 39 years (IPCS, 1992; WMO, 2011).

The overall lifetime for the chemical in the atmosphere is 5 years. This lifetime takes into account all major loss mechanisms such as reactions with hydroxyl radicals, destruction in the stratosphere and uptake by oceans (WMO, 2011). This lifetime significantly exceeds the domestic criterion for environment persistence (half life = 2 days). The chemical is therefore categorised as persistent.

Bioaccumulation

The measured bioconcentration factors (BCFs) for the chemical in fish are ≤ 4.9 L/kg for *Cyprinus carpio* and ≤ 9 L/kg for *Lepomis macrochirus*. The bio-elimination half-life in *L. macrochirus* has been determined to be less than 24 hours after concentrations reach equilibrium in the tissues (OECD, 2009). These BCFs and the bio-elimination half-life indicate a limited potential for bioaccumulation in aquatic organisms.

Transport

The chemical is exclusively of anthropogenic origin and has become a globally distributed pollutant. The major route for global distribution of the chemical is through transport in the atmosphere. The chemical is also transported to the stratosphere where it is eventually degraded by UV photolysis (IPCS, 1992).

Predicted Environmental Concentration (PEC)

1,1,1-Trichloroethane is not expected to be released to the environment due to industrial use in Australia, as release of the chemical is prohibited by the Ozone Act. As no environmental release resulting from current industrial uses is expected, the PEC for this chemical has not been calculated.

Nevertheless, the chemical may be present in the environment due to historical industrial uses. In a NSW study conducted between 1996 and 2001, the chemical was detected in 4 to 5% of air samples tested at concentrations up to 4.32 μg/m^3. The overall annual average in the test period was 0.54 μg/m^3 (NSW DEC, 2004). Internationally, the World Health Organisation (WHO) has reported median 1,1,1-trichloroethane air concentrations of 0.6 μg/m^3 in rural and remote areas, 2.8 μg/m^{3}in urban and suburban areas, and 6.5 μg/m^3 in areas around emission sources. Mean air concentrations in cities in the United States ranged from 0.001 to 60 μg/m^3 for urban air and 0.36 to 1.08 μg/m^3 for rural air (WHO, 2003).

The review conducted by the World Health Organisation in 2003 also noted that concentrations of 1,1,1-trichloroethane are typically higher in the northern hemisphere than the southern hemisphere (WHO, 2003). However, more recent global monitoring data have shown that the abundance of this chemical in the atmosphere has been steadily decreasing since the mid 1990s and the differences between the atmospheric levels of the chemical in the two hemispheres (based on surface mixing ratios) is now much less than it was in the 1980s before global emissions were reduced (WMO, 2011).

Environmental Effects

Effects on the Atmosphere

The stratospheric ozone layer protects life on Earth by absorbing UV radiation from the sun. This form of radiation can be damaging to most forms of life on Earth (Australian Government Department of the Environment, 2013c). Therefore, the destruction of ozone in the upper atmosphere is of environmental concern.

Photolysis of 1,1,1-trichloroethane in the stratosphere by high-energy UV radiation liberates highly reactive chlorine atoms. These chlorine atoms undergo reactions that destroy ozone and hence deplete the capacity of the ozone layer to absorb harmful UV radiation. The impact of ozone depleting chemicals on the stratospheric ozone is typically reported in terms of the ozone depletion potential (ODP) metric. The ODP is the ratio of the impact of the substance on ozone compared to the impact of the same mass of the chlorofluorocarbon, trichlorofluoromethane (CFC-11) (US EPA, 2010; WMO, 2011). 1,1,1-Trichloroethane is assigned an ODP of 0.1 under the Ozone Act (Commonwealth of Australia, 1989).

Halocarbons with long atmospheric lifetimes such as 1,1,1-trichloroethane also contribute to global warming by absorbing radiation emitted from Earth and thus trapping the energy in the atmosphere (radiative forcing) (WMO, 2011). The amount of global warming that can be caused by a substance is typically reported in terms of the global warming potential (GWP) metric. The GWP is the ratio of the warming caused by the substance to the warming caused by the same mass of carbon dioxide, and is calculated for various time horizons (US EPA, 2010; WMO, 2011). 1,1,1-Trichloroethane has a one hundred year GWP of 110–146 (US EPA, 2013c; WMO, 2011).

Effects on Aquatic Life

There are significant quantities of measured aquatic ecotoxicological data available for this chemical (IPCS, 1992; LMC, 2013;OECD, 2009). Endpoints identified and used to characterise the acute and chronic effects of this chemical on major aquatic trophic levels include median lethal concentrations (LC50s), median effective concentrations (EC50s), no-observed-effect concentrations (NOECs) and effective concentrations for 10% of the test population (EC10s), as detailed below.

Acute toxicity

The following acute ecotoxicity endpoints for a taxonomic group from each aquatic trophic level were reported in the OECD SIDS Initial Assessment Report (SIAR) for 1,1,1-trichloroethane and the databases included in the OECD QSAR Toolbox (LMC, 2013; OECD, 2009):

Taxon	Endpoint	Method

Taxon	Endpoint	Method
Fish	96 h LC50 = 11.1 mg/L	Experimental (flow-though)
Invertebrates	48 h EC50 = 11.2 mg/L	Experimental (static)
Algae	72 h EC50 = 0.536 mg/L	Experimental (similar to DIN 38412 Part 33, gas-tight static system, measured test concentrations)

In addition, a prolonged (14 day) fish study conducted in accordance with OECD TG 204, under flow-through conditions, found a NOEC of 7.7 mg/L (OECD, 2009).

Algae is the most sensitive taxonomic group to acute toxic effects of this chemical based on these data. Based on the median effective concentration for algae and the domestic criteria for the categorisation of ecotoxicity, the chemical is categorised as toxic (T) to aquatic organisms (EPHC, 2009; NICNAS, 2013).

Chronic toxicity

The following chronic ecotoxicity endpoints for a taxonomic group from two aquatic trophic levels were reported in the OECD SIAR for 1,1,1-trichloroethane (OECD, 2009):

Taxon	Endpoint	Method
Invertebrates	17 d NOEC (reproduction) = 1.3 mg/L	Experimental (OECD TG 202 Part II, semi-static, measured test concentrations)
Algae	72 h EC10 = 0.213 mg/L	Experimental (similar to DIN 38412 Part 33, gas-tight static system, measured test concentrations)

Although the reported aquatic invertebrate study is shorter in duration than conventional aquatic invertebrate chronic toxicity tests, it is appropriate to consider it a chronic endpoint (e.g., UNECE, 2009).

Algae is the most sensitive taxonomic group to chronic toxic effects of this chemical based on these data.

Predicted No-Effect Concentration (PNEC)

The PNEC for the chemical in the air compartment was not calculated. The current global consensus is that emissions of this chemical should be minimised in order to maintain the health of the ozone layer and to reduce global warming resulting from pollutants entering the atmosphere.

The PNEC for the chemical in the aquatic compartment was calculated to be 4.3 µg/L. This value was derived from the effective concentration for 10% of the test population of algae (72 h EC10 = 0.213 mg/L) with the application of an assessment factor of 50. An assessment factor of 50 for this calculation was selected as reliable chronic ecotoxicity data are available for species from two aquatic trophic levels (EPHC, 2009).

Categorisation of Environmental Hazard

Persistence

Persistent (P). The chemical is not rapidly degraded by natural processes in the environment and has a half life of greater than 2 days in air and 60 days in water. Therefore, the chemical is categorised as Persistent.

Bioaccumulation

Not Bioaccumulative (Not B). The chemical has low potential for bioaccumulation and does not have a BCF greater than 2000 in aquatic organisms. The chemical is therefore categorised as Not Bioaccumulative.

Toxicity

Toxic (T). The chemical is expected to be toxic to aquatic organisms, as the measured acute toxicity to algae is less than 1 mg/L. Therefore, the chemical is categorised as Toxic.

Summary

1,1,1-Trichloroethane is categorised according to domestic environmental hazard thresholds (NICNAS, 2013) as:

- P
- Not B
- T

Risk Characterisation

Risk quotients (RQs) have not been calculated for this chemical.

The international consensus is that release of this chemical to the atmosphere poses a risk to the environment. However, as environmental exposure in Australia is controlled under the Ozone Act, the risk to the atmosphere resulting from current industrial uses of the chemical is low.

A PEC was not calculated for the aquatic compartment as there is limited potential for release of the chemical to the aquatic environment. The risk to the aquatic environment resulting from current industrial use of the chemical is low.

The risks to the soil and sediment compartments are expected to be low as the chemical is not expected to partition to these compartments.

Key Findings

The release of 1,1,1-trichloroethane to the environment is of concern due to the ozone depleting and global warming properties of the chemical. However, the manufacture, import and export of 1,1,1-trichloroethane is controlled in Australia under the Ozone Act and no environmental release of the chemical due to industrial use is expected. Therefore, current industrial use of the chemical is not expected to be of concern to the environment.

The chemical is not a PBT substance according to domestic environmental hazard criteria.

Recommendations

The manufacture, import and export of ethane, 1,1,1-trichloro- (1,1,1-trichloroethane) is controlled in Australia under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989*. The control measures implemented under the Act are expected to prevent environmental exposures of this chemical from industrial use. Current risk management measures are therefore considered adequate to protect the environment. No further assessment is required.

Environmental Hazard Classification

In addition to the categorisation of environmental hazards according to domestic environmental thresholds presented above, the classification of the environmental hazards of 1,1,1-trichloroethane according to the third edition of the United Nations' Globally Harmonised System of Classification and Labelling of Chemicals (GHS) is presented below (UNECE, 2009):

Hazard	GHS Classification (Code)	Hazard Statement
Acute Aquatic	Category 1 (H400)	Very toxic to aquatic life
Chronic Aquatic	Category 2 (H411)	Toxic to aquatic life with long lasting effects
Ozone Layer	Category 1 (H420)	Harms public health and the environment by destroying ozone in the upper atmosphere

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