United States Environmental Protection Agency

Technical Fact Sheet – 1,2,3-Trichloropropane (TCP)

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TECHNICAL FACT SHEET – 1,2,3,-TCP

At a Glance

- Colorless to straw-colored liquid.
- Not found in nature – completely man-made compound.
- Not likely to sorb to soil and likely to either leach from soil into groundwater. In the pure form, likely to exist as a dense nonaqueous phase liquid.
- Exposure occurs from industrial settings or hazardous waste sites.
- EPA has classified TCP as "likely to be carcinogenic to humans" and lists a chronic oral reference dose (RfD) of 4 x 10^{-3} milligrams per kilogram per day.
- Short-term exposure may cause eye and throat irritation; long-term exposure has led to liver and kidney damage and reduced body weight in animal studies.
- Federal maximum contaminant level (MCL) not established for TCP in drinking water.
- Federal screening levels, state health-based drinking water guidance values and federal occupational exposure limits have been established.
- Numerous methods are available for detection, including gas chromatography, mass spectroscopy and liquid-liquid extraction.
- Remediation technologies available to treat TCP contamination in groundwater and soil include granular activated carbon (GAC), dechlorination by hydrogen release compound (HRC®), reductive dechlorination by zero valent zinc and others.

Introduction

This fact sheet, developed by the U.S. Environmental Protection Agency (EPA) Federal Facilities Restoration and Reuse Office (FFRRO), provides a summary of the contaminant 1,2,3-trichloropropane (TCP), including physical and chemical properties; environmental and health impacts; existing federal and state guidelines; detection and treatment methods; and sources of additional information. This fact sheet is intended for use by site managers and other field personnel in addressing TCP contamination at cleanup sites or in drinking water supplies.

TCP is a contaminant of interest to the government, private sector and other parties. It is a persistent pollutant in groundwater and has been classified as "likely to be carcinogenic to humans" by the EPA.

What is TCP?

- TCP is a chlorinated hydrocarbon with high chemical stability (Samin and Janssen 2012).
- Synonyms include allyl trichloride, glycerol trichlorohydrin and trichlorohydrin (OSHA 2013).
- TCP is exclusively a man-made chemical, typically found at industrial or hazardous waste sites (Dombeck and Borg 2005; ATSDR 1992).
- TCP has been used as an industrial solvent and as a cleaning and degreasing agent; it has been found as an impurity resulting from the production of soil fumigants (DHHS 2011; HSDB 2009).
- TCP is currently used as a chemical intermediate in the production of other chemicals (including polysulfone liquid polymers and dichloropropene), and in the synthesis of hexafluoropropylene. In addition, it is used as a crosslinking agent in the production of polysulfides (DHHS 2011; HSDB 2009).

What are the environmental impacts of TCP?

- TCP is not likely to sorb to soil based on its low soil organic carbon-water partition coefficient; therefore, it is likely to either leach from soil into groundwater or evaporate from soil surfaces (ATSDR 1992; HSDB 2009).

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Exhibit 1: Physical and Chemical Properties of TCP
(ATSDR 1992; DHHS 2011; Dombeck and Borg 2005; HSDB 2009)

Property	Value
Chemical Abstracts Service (CAS) Number	96-18-4
Physical Description (at room temperature)	Colorless to straw-colored liquid
Molecular weight (g/mol)	147.43
Water solubility at 25°C (mg/L)	1,750 (slightly soluble)
Melting point (°C)	-14.7
Boiling point (°C)	156.8
Vapor pressure at 25°C (mm Hg)	3.1 to 3.69
Specific gravity at 20/4 °C (g/cm^3)	1.3889
Octanol-water partition coefficient (log K_{ow})	1.98 to 2.27 (temperature dependent)
Organic carbon-water partition coefficient (log K_{oc})	1.70 to 1.99 (temperature dependent)
Henry's law constant at 25°C (atm-m^3/mol)	3.17 x 10^{-4} (ATSDR 1992) ; 3.43 x 10^{-4} (Dombeck and Borg 2005)

Abbreviations: g/mol – gram per mole; mg/L – milligrams per liter; °C – degrees Celsius; g/cm^3 – grams per cubic meter; mm Hg – millimeters of mercury; atm-m^3/mol – atmosphere-cubic meters per mole.

What are the environmental impacts of TCP? (continued)

- As a result of low abiotic and biotic degradation rates, TCP may remain in groundwater for long periods of time (ATSDR 1992; Samin and Janssen 2012).
- TCP will sink to the bottom of a groundwater aquifer because its density is greater than that of water. Therefore, TCP in pure form is likely to exist as dense nonaqueous phase liquid (Cal/EPA 2009).
- TCP is expected to exist solely as a vapor in the ambient atmosphere and is subject to photodegradation by reaction with hydroxyl radicals, with and estimated half-life ranging from 15 to 46 days (DHHS 2011; HSDB 2009; Samin and Janssen 2012).
- TCP is unlikely to become concentrated in plants, fish or other aquatic organisms because it has a low estimated bioconcentration factor (BCF) range of 5.3 to 13 (ATSDR 1992, 1995; HSDB 2009).

What are the routes of exposure and the health effects of TCP?

- Exposure occurs through vapor inhalation, dermal exposure or ingestion (ATSDR 1995; DHHS 2011).
- Exposure is most likely to occur near hazardous waste sites where TCP was improperly stored or disposed, or at locations that manufacture or use the chemical (ATSDR 1992; DHHS 2011).
- EPA has classified TCP as "likely to be carcinogenic to humans" based on the formation of multiple tumors in animals (EPA IRIS 2009).
- The U.S. Department of Health and Human Services states that TCP is reasonably anticipated to be a human carcinogen based on sufficient evidence of carcinogenicity from studies in experimental animals (DHHS 2011).
- The American Conference of Governmental Industrial Hygienists (ACGIH) has classified TCP as a Group A3 carcinogen: a confirmed animal carcinogen with unknown relevance to humans (ACGIH 2009).
- The National Institute for Occupational Safety and Health (NIOSH) considers TCP a potential occupational carcinogen (NIOSH 2010).
- TCP is recognized by the State of California as a human carcinogen (Cal/EPA 2013).
- Animal studies have shown that long-term exposure to TCP may cause liver and kidney damage, reduced body weight and increased incidences of tumors in numerous organs (ATSDR 1992; DHHS 2011; EPA IRIS 2009).
- Short-term exposure to high levels of TCP may cause irritation of eyes, skin and the respiratory tract, and depression of the central nervous system (HSDB 2009; NIOSH 2010). In addition, it may affect concentration, memory and muscle coordination (Cal/EPA 2009).
- Studies indicate that short-term exposure through inhalation of air with a TCP concentration of 100 parts per million (ppm) can cause eye and throat irritation (HSDB 2009; ATSDR 1995).

Are there any federal and state guidelines and health standards for TCP?

- The EPA Integrated Risk Information System (IRIS) lists a chronic oral reference dose (RfD) of 4 x 10^{-3} milligrams per kilogram per day (mg/kg/day) and a chronic inhalation reference concentration (RfC) of 3 x 10^{-4} milligrams per cubic meter (mg/m^3) (EPA IRIS 2009).
- The cancer risk assessment for TCP is based on an oral slope factor of 30 mg/kg/day (EPA IRIS 2009).
- The Agency for Toxic Substances and Disease Registry (ATSDR) has established a minimal risk level (MRL) of 0.003 ppm for acute-duration (14 days or less) oral exposure to TCP and an MRL of 0.08 mg/kg/day for chronic-duration (365 days or more) oral exposure to TCP (ATSDR 2013).
- The EPA has established drinking water health advisories for TCP, which are drinking water specific risk level concentrations for cancer (10^{-4} cancer risk) and concentrations of drinking water contaminants at which noncancer adverse health effects are not anticipated to occur over specific exposure durations. EPA established a 1-day health advisory of 0.6 milligrams per liter (mg/L) and a 10-day health advisory of 0.6 mg/L for TCP in drinking water for a 10 kilogram (kg) child (EPA 2012a).
- The EPA's drinking water equivalent level (DWEL) for TCP is 0.1 mg/L (EPA 2012a).
- EPA has calculated a residential soil screening level (SSL) of 5.0 x 10^{-3} milligrams per kilogram (mg/kg) and an industrial SSL of 9.5 x 10^{-2} mg/kg. The soil-to-groundwater risk-based SSL is 2.8 x10^{-7} mg/kg (EPA 2013).[1]
- EPA has also calculated a residential air screening level of 3.1 x 10^{-1} micrograms per cubic meter ($\mu g/m^3$) and an industrial air screening level of 1.3 $\mu g/m^3$ (EPA 2013).
- For tap water, EPA has calculated a screening level of 6.5 x 10^{-4} micrograms per liter (µg/L) (EPA 2013).
- No federal maximum contaminant level (MCL) has been set for TCP in drinking water (EPA 2013).
- EPA included TCP on the third Contaminant Candidate List (CCL3), which is a list of unregulated contaminants that are known to, or anticipated to, occur in public water systems and may require regulation under the Safe Drinking Water Act (SDWA) (EPA 2009).
- In addition, EPA added TCP to its Unregulated Contaminant Monitoring Rule (UCMR) 3, requiring many large water utilities to monitor for TCP with a minimum reporting level of 0.03 µg/L. The EPA uses the UCMR to monitor contaminants suspected to be present in drinking water that do not currently have health-based standards under the SDWA (EPA 2012b).
- The Occupational Safety and Health Administration (OSHA) has established a general industry permissible exposure limit of 50 ppm (300 mg/m^3) based on an 8-hour time weighted average (TWA) exposure (OSHA 2013).
- NIOSH has set a recommended exposure limit of 10 ppm (60 mg/m^3) based on a 10-hour TWA exposure and an immediately dangerous to life and health level of 100 ppm (NIOSH 2010).
- ACGIH has set a threshold limit value of 10 ppm (60 mg/m^3) based on an 8-hour TWA exposure (ACGIH 2009).
- The State of Hawaii has established a state MCL of 0.6 µg/L, and the California Department of Public Health (CDPH) is currently developing a state MCL, which is expected to be released for public comment in 2014 (CDPH 2013; Hawaii Department of Health 2011).
- The CDPH has established a notification level of 0.005 µg/L for drinking water based on a 1 in 10^{-6} lifetime excess cancer risk and has set a final public health goal of 0.0007 µg/L (CDPH 2010, 2013).
- Various other states have also established health-based drinking water guidance values, including the Minnesota Department of Health (0.003 µg/L) and the New Jersey Department of Environmental Protection (0.005 µg/L) (MDH 2011; NJDEP 2008).

[1] Screening Levels are developed using risk assessment guidance from the EPA Superfund program. These risk-based concentrations are derived from standardized equations combining exposure information assumptions with EPA toxicity data. These calculated screening levels are generic and not enforceable cleanup standards but provide a useful gauge of relative toxicity.

What detection and site characterization methods are available for TCP?

- EPA SW-846 Method 8260B uses gas chromatography (GC)/mass spectrometry (MS) for the detection of TCP in solid waste matrices (EPA 1996).
- EPA Method 551.1 uses liquid-liquid extraction and GC with electron-capture detection, for the detection of TCP in drinking water, drinking water during intermediate stages of treatment and raw source water (ATSDR 2011; EPA ORD 1990).
- EPA Method 504.1 uses microextraction and GC, for the detection of TCP in groundwater and drinking water (ATSDR 2011; EPA ORD 1995).
- EPA Method 524.3 uses capillary column GC/MS, for the detection of TCP in treated drinking water (EPA OGWDW 2009).
- CDPH methods, uses liquid-liquid extraction and GC/MS and purge and trap GC/MS, for trace-level detection of TCP in drinking water (CDPH 2002a, b).

What technologies are being used to treat TCP?

- Treatment technologies for groundwater that are available for remediation of chlorinated hydrocarbons include pump and treat, permeable reactive barriers, in situ chemical oxidation and bioremediation (reductive dechlorination) (Cal/EPA 2009).
- TCP in water can be removed using granular activated carbon (GAC); however, TCP has only a low to moderate adsorption capacity for GAC and may require a larger GAC treatment system, thereby, increasing treatment costs (Dombeck and Borg 2005; Molnaa 2003; Tratnyek and others 2008).
- In a full-scale study, hydrogen release compound (HRC®) successfully reduced TCP to non-detect levels through the promotion of anaerobic reductive dechlorination of TCP in groundwater (Tratnyek and others 2008).
- Treatment for TCP in water using ultraviolet radiation and chemical oxidation with potassium permanganate has achieved some success for low-flow systems (Dombeck and Borg 2005; Cal/EPA 2009).
- Bench-scale tests have also investigated chemical oxidation with Fenton's reagent for the treatment of TCP in groundwater. A study found that Fe(2+) was the most effective type of iron at reducing TCP (Khan and others 2009; Samin and Janssen 2012).
- Bench-scale tests have shown evidence of TCP degradation in water using advanced oxidation processes involving ozone and hydrogen peroxide (Dombeck and Borg 2005).
- Bench-scale tests using zero-valent iron have shown limited degradation of TCP in saturated soil and groundwater (Samin and Janssen 2012; Sarathy and others 2010; Tratnyek and others 2008, 2010).
- Bench- and field-scale studies have identified granular zero valent zinc as an effective reductant for remediation of TCP in groundwater, with more rapid degradation compared with granular zero-valent iron and limited accumulation of intermediate products (ATSDR 2011; Sarathy and others 2010; Salter-Blanc and others 2012; Tratnyek and others 2010).
- Recent studies are investigating the use of genetically engineered strains of *Rhodococcus* for the complete biodegradation of TCP under aerobic conditions (Samin and Janssen 2012).

Where can I find more information about TCP?

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Where can I find more information about TCP? (continued)

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Where can I find more information about TCP? (continued)

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Contact Information

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