United States Environmental Protection Agency

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

November 2017

At a Glance

- Produced as a chemical intermediate.
- Formerly used as a paint and varnish remover, solvent and degreasing agent.
- Evaporates readily from surface soil and surface water and travels quickly from subsurface soil to groundwater.
- In the pure form, likely to exist as a dense nonaqueous phase liquid.
- Primary human exposure routes are inhalation of ambient air and ingestion of drinking water.
- EPA has classified TCP as "likely to be carcinogenic to humans."
- 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.
- A federal maximum contaminant level (MCL) has not been established for TCP in drinking water; federal and state health-based screening levels have been established.
- 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 and for those in a position to consider whether TCP should be added to the analytical suite for site investigations.

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 EPA (EPA 2009).

What is TCP?

- TCP is exclusively a man-made chlorinated hydrocarbon, typically found at industrial or hazardous waste sites (Dombeck and Borg 2005; ATSDR 1992). TCP is often present at sites contaminated by other chlorinated solvents (Dombeck and Borg 2005).
- 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 (NTP 2016; HSDB 2009).
- TCP is used as a chemical intermediate in the production of other chemicals such as liquid polymers (NTP 2016; HSDB 2009).

Exhibit 1: Physical and Chemical Properties of TCP
(EPA 2017b; NTP 2016; 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 (high)
Specific gravity at 20°C (g/cm^3)	1.3889
Octanol-water partition coefficient (log K_{ow})	1.98 to 2.27 (temperature dependent)
Soil organic carbon-water partition coefficient (log K_{oc})	1.70 to 1.99 (temperature dependent)
Henry's law constant at 25°C ($atm\text{-}m^3/mol$)	3.43×10^{-4} (HSDB 2009; Dombeck and Borg 2005)

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

Existence of TCP in the environment

- 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).
- 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 in pure form is likely to exist as dense nonaqueous phase liquid and thus, will sink to the bottom of a groundwater aquifer because its density is greater than that of water (Cal/EPA 2016a).
- TCP is expected to exist solely as a vapor in the ambient atmosphere and is subject to photodegradation by reaction with hydroxyl radicals, with an estimated half-life ranging from 15 to 46 days (NTP 2016; 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; HSDB 2009).

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

- Exposure to the general population primarily occurs through vapor inhalation or ingestion of contaminated water (ATSDR 1995; NTP 2016).
- Exposure is most likely to occur near hazardous waste sites where TCP was improperly stored or disposed of, or at locations that manufacture or use the chemical (ATSDR 1992; NTP 2016).
- EPA has classified TCP as "likely to be carcinogenic to humans" based on the formation of multiple tumors in animals (EPA 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 (NTP 2016).
- The American Conference of Governmental Industrial Hygienists classified TCP as a Group A3 carcinogen: a confirmed animal carcinogen with unknown relevance to humans (HSDB 2009).
- The National Institute for Occupational Safety and Health considers TCP a potential occupational carcinogen (NIOSH 2010).
- TCP is recognized by the State of California as a human carcinogen (Cal/EPA 2016b).
- 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; NTP 2016; EPA 2009).
- Short-term inhalation 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 2016a).

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 2009).
- The cancer risk assessment for TCP is based on an oral slope factor of 30 mg/kg/day (EPA 2009).
- The Agency for Toxic Substances and Disease Registry (ATSDR) has established a minimal risk level (MRL) of 0.0003 ppm for acute-duration (14 days or less) inhalation exposure to TCP and an MRL of 0.06 mg/kg/day for intermediate-duration (>14 days to 364 days) oral exposure to TCP (ATSDR 2017).
- EPA has established drinking water health advisories for TCP, 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 and a 10-day noncancer health advisory of 0.6 milligrams per liter (mg/L) for TCP in drinking water for a 10-kilogram (kg) child (EPA 2012).
- EPA's drinking water equivalent level (DWEL) for TCP is 0.1 mg/L based on lifetime exposure and noncancer effects (EPA 2012).
- EPA has calculated a residential soil screening level (SSL) of 5.1 x 10^{-3} milligrams per kilogram (mg/kg) and an industrial SSL of 0.11 mg/kg. The soil-to-groundwater risk-based SSL is 3.2 x 10^{-7} mg/kg (EPA 2017b).
- 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 2017b).
- For tap water, EPA has calculated a screening level of 7.5 x 10^{-4} micrograms per liter (µg/L) (EPA 2017b).
- No federal maximum contaminant level (MCL) has been set for TCP in drinking water (EPA 2017a).
- EPA included TCP on the fourth Contaminant Candidate List (CCL4), 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 2016b).
- 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. 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 2016a).
- California has established a state MCL of 0.005 µg/L (Cal/EPA 2017). Hawaii has established a state MCL of 0.6 µg/L (HDH 2014).
- Various other states have established health-based levels in drinking water ranging from 3 x 10^{-5} µg/L in Texas (TCEQ 2017) to 40 µg/L in New York (NYDEC 2016).
- Several states (Nebraska, North Carolina and West Virginia) (Nebraska 2012; North Carolina 2016; West Virginia 2014) have established residential SSLs similar to EPA's regional screening levels (RSLs). Some states developed levels much higher, ranging from 0.05 mg/kg in New Mexico (2017) to 1,300 mg/kg in Michigan (2013).

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 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 TCP in groundwater include traditional methods such as pump and treat, permeable reactive barriers, in situ chemical oxidation and bioremediation (reductive dechlorination) (Cal/EPA 2016a).
- 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, increasing treatment costs (Dombeck and Borg 2005; Cal/EPA 2016a; 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 2016a).
- 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 to levels as low as 0.005 µg/l using advanced oxidation processes involving ozone and hydrogen peroxide (Cal/EPA 2016a; Dombeck and Borg 2005).
- Bench-scale tests using zero-valent iron have shown limited degradation of TCP in saturated soil and groundwater (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?

- Agency for Toxic Substances and Disease Registry (ATSDR). 1992. "Toxicological Profile for 1,2,3-Trichloropropane." www.atsdr.cdc.gov/toxprofiles/tp57.pdf
- ATSDR. 1995. ToxFAQs "1,2,3-Trichloro-propane." www.atsdr.cdc.gov/toxfaqs/tfacts57.pdf
- ATSDR. 2011. "Addendum to the Toxicological Profile for 1,2,3-Trichloropropane." www.atsdr.cdc.gov/toxprofiles/1_2_3_trichloropropane_addendum.pdf
- ATSDR. 2017. "Minimal Risk Levels (MRLs)." www.atsdr.cdc.gov/mrls/pdfs/atsdr_mrls.pdf
- California Department of Public Health (CDPH). 2002a. "Determination of 1,2,3-Trichloropropane in Drinking Water by Continuous Liquid-Liquid Extraction and Gas Chromatography/Mass Spectrometry." www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/drinkingwaterlabs/TCPbyLLE-GCMS.pdf
- CDPH. 2002b. "Determination of 1,2,3-Trichloropropane in Drinking Water by Purge and Trap Gas Chromatography/Mass Spectrometry." www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/drinkingwaterlabs/TCPbyPT-GCMS.pdf
- California Environmental Protection Agency (Cal/EPA). 2016a. State Water Resources Control Board. "Groundwater Information Sheet 1,2,3-Trichloropropane." Division of Water Quality. Groundwater Ambient Monitoring and Assessment (GAMA) Program. www.waterboards.ca.gov/gama/docs/coc_tcp123.pdf
- Cal/EPA. 2016b. "Chemicals Known to the State to Cause Cancer or Reproductive Toxicity." oehha.ca.gov/proposition-65/proposition-65-list
- California Environmental Protection Agency (Cal/EPA). 2017. State Water Resources Control Board. 1,2,3,-Trichloropropane. www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/123TCP.shtml

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

- Dombeck, G., and C. Borg. 2005. "Multi-contaminant Treatment for 1,2,3 TCP Destruction Using the HiPOx Reactor." National Groundwater Association (NGWA) Conference on MTBE and Perchlorate: Assessment, Remediation, and Public Policy with permission of the NGWA Press. citrix.ngwa.org/gwol/pdf/062181324.pdf
- Hawaii Department of Health (HDH). 2014. Administrative Rules. Title 11. Chapter 20. Rules Relating to Potable Water Systems. Page 20-20. health.hawaii.gov/opppd/files/2015/06/11-20-2014.pdf
- Hazardous Substances Data Bank (HSDB). 2009. "1,2,3-Trichloropropane." toxnet.nlm.nih.gov/newtoxnet/hsdb.htm
- Khan, E., Wirojanagud, W., and N. Sermsai. 2009. "Effects of Iron Type in Fenton Reaction on Mineralization and Biodegradability Enhancement of Hazardous Organic Compounds." Journal of Hazardous Materials. Volume 161 (2 to 3). Pages 1024 to 1034.
- Michigan Department of Environmental Quality. 2013. Cleanup Criteria Requirements for Response Activity. www.michigan.gov/deq/0,4561,7-135-3311_4109-251790--,00.html
- National Institute for Occupational Safety and Health (NIOSH). 2010. "1,2,3-Trichloropropane." NIOSH Pocket Guide to Chemical Hazards. www.cdc.gov/niosh/npg/npgd0631.html
- National Toxicology Program (NTP). 2016. "14th Report on Carcinogens." Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service. ntp.niehs.nih.gov/pubhealth/roc
- Nebraska Department of Environmental Quality. 2012. Voluntary Cleanup Remediation Goals. deq.ne.gov/Publica.nsf/xsp/.ibmmodres/domino/OpenAttachment/Publica.nsf/D243C2B56E34EA8486256F2700698997/Body/ATTIY3JX.pdf
- New Mexico Environment Department. 2017. Soil Screening Levels. www.env.nm.gov/hazardous-waste/guidance-documents/
- New York Department of Environmental Conservation (NYDEC). 2016. Water Quality Standards.govt.westlaw.com/nycrr/Document/I4ed90418cd1711dda432a117e6e0f345?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)&bhcp=1
- North Carolina Department of Environmental Quality. 2016. Preliminary Soil Remediation Goals. ncdenr.s3.amazonaws.com/s3fs-public/Waste%20Management/DWM/SF/IHS/guidance/SoilTable%20APRIL%202016%20-Final-1pcb1.pdf
- Salter-Blanc, A.J., Suchomel, E.J., Fortuna, J.H., Nurmi, J.T., Walker, C., Krug, T., O'Hara, S., Ruiz, N., Morley, T., and P.G. Tratnyek. 2012. "Evaluation of Zero-valent Zinc for Treatment of 1,2,3-Trichloropropane-Contaminated Groundwater: Laboratory and Field Assessment." Groundwater Monitoring and Remediation. Volume 32 (4). Pages 42 to 52.
- Samin, G., and D.B. Janssen. 2012. "Transformation and Biodegradation of 1,2,3-Trichloropropane (TCP)." Environmental Science and Pollution Research International. Volume 19 (8). Pages 3067 to 3078.
- Sarathy, V., Salter, A.J., Nurmi, J.T., Johnson, G.O., Johnson, R.L., and P.G. Tratnyek. 2010. "Degradation of 1,2,3-Trichloropropane: Hydrolysis, Elimination, and Reduction by Iron and Zinc." Environmental Science Technology. Volume 44. Pages 787 to 793.
- Texas Commission of Environmental Quality (TCEQ). 2017. Protective Concentration Levels. www.tceq.texas.gov/remediation/trrp/trrppcls.html
- Tratnyek, P.G., Sarathy, V., and J.H. Fortuna. 2008. "Fate and Remediation of 1,2,3-Trichloropropane." Remediation of Chlorinated and Recalcitrant Compounds-2008. Proceedings of the Sixth International Conference on Remediation of Chlorinated and Recalcitrant Compounds. Monterey, CA. May 2008.
- Tratnyek, P.G., Sarathy, V., Salter, A.J., Nurmi, J.T., Johnson, G., DeVoe, T., and P. Lee. 2010. "Prospects for Remediation of 1,2,3-Trichloropropane by Natural and Engineered Abiotic Degradation Reactions."SERDP Project ER-1457. www.serdp-estcp.org/content/download/9291/110767/file/ER-1457-FR.pdf
- U.S. Environmental Protection Agency (EPA). 1996. Method 8260B. "Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)." Revision 2. www.epa.gov/sites/production/files/2015-12/documents/8260b.pdf

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

- EPA. 2009. Integrated Risk Information System (IRIS). 1,2,3-Trichloropropane; CASRN 96-18-4. cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0200_summary.pdf
- EPA. 2012. "2012 Edition of the Drinking Water Standards and Health Advisories." www.epa.gov/dwstandardsregulations/drinking-water-contaminant-human-health-effects-information#dw-standards
- EPA. 2016a. Methods and Contaminants for the Unregulated Contaminant Monitoring Rule 3 (UCMR 3). www.epa.gov/dwucmr/third-unregulated-contaminant-monitoring-rule
- EPA. 2016b. Contaminant Candidate List 4-CCL 4. www.epa.gov/ccl/contaminant-candidate-list-4-ccl-4-0
- EPA. 2017a. National Primary Drinking Water Regulations. www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations
- EPA. 2017b. Regional Screening Levels (RSLs). www.epa.gov/risk/regional-screening-levels-rsls
- EPA. Office of Groundwater and Drinking Water (OGWDW). 2009. Method 524.3. "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry." Version 1.0. Technical Support Center. www.nemi.gov/methods/method_pdf/10417
- EPA. Office of Research and Development (ORD). 1990. Method 551.1. "Determination of Chlorination Disinfection Byproducts, Chlorinated Solvents, and Halogenated Pesticides/Herbicides in Drinking Water by Liquid-Liquid Extraction and Gas Chromatography with Electron-Capture Detection." Revision 1.0. National Exposure Research Laboratory. www.nemi.gov/methods/method_pdf/4809/
- EPA. ORD. 1995. Method 504.1. "1,2-Dibromoethane (EDB), 1,2-Dibromo-3-chloropropane (DBCP), and 1,2,3-Trichloropropane (123TCP) in Water by Microextraction and Gas Chromatography." Revision 1.1. National Exposure Research Laboratory.
- West Virginia Department of Environmental Protection. 2014. www.dep.wv.gov/dlr/oer/voluntarymain/Documents/Effective%20June%2001%202014%20De%20Minimis%20Table-V2.zip

Contact Information

If you have any questions or comments on this fact sheet, please contact: Mary Cooke, FFRRO, at cooke.maryt@epa.gov.