ENVIRONMENTAL CONTAMINANTS ENCYCLOPEDIA
TRICHLOROETHYLENE ENTRY

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Like a library or many large databases (such as EPA's national STORET water quality database), this document contains information of variable quality from very diverse sources. In compiling this document, mistakes were found in peer reviewed journal articles, as well as in databases with relatively elaborate quality control mechanisms [366,649,940]. A few of these were caught and marked with a "[sic]" notation, but undoubtedly others slipped through. The [sic] notation was inserted by the editors to indicate information or spelling that seemed wrong or misleading, but which was nevertheless cited verbatim rather than arbitrarily changing what the author said.

Most likely additional transcription errors and typos have been added in some of our efforts. Furthermore, with such complex subject matter, it is not always easy to determine what is correct and what is incorrect, especially with the "experts" often disagreeing. It is not uncommon in scientific research for two different researchers to come up with different results which lead them to different conclusions. In compiling the Encyclopedia, the editors did not try to resolve such conflicts, but rather simply reported it all.

It should be kept in mind that data comparability is a major problem in environmental toxicology since laboratory and field methods are constantly changing and since there are so many different "standard methods" published by EPA, other federal agencies, state agencies, and various private groups. What some laboratory and field investigators actually do for standard operating practice is often a unique combination of various standard protocols and impromptu "improvements." In fact, the interagency task force on water methods concluded that [1014]:

> It is the exception rather than the rule that water-quality monitoring data from different programs or time periods can be compared on a scientifically sound basis, and that...
>
> No nationally accepted standard definitions exist for water quality parameters. The different organizations may collect data using identical or standard methods, but identify them by different names, or use the same names for data collected by different methods [1014].

Differences in field and laboratory methods are also major issues related to (the lack of) data comparability from media other than water: soil, sediments, tissues, and air.

In spite of numerous problems and complexities, knowledge is often power in decisions related to chemical contamination. It is therefore often helpful to be aware of a broad universe of conflicting results or conflicting expert opinions rather than having a portion of this information arbitrarily censored by someone else. Frequently one wants to know of the existence of information, even if one later decides not to use it for a particular application. Many would like to see a high percentage of the information available and decide for themselves what to throw out, partly because they don't want to seem uniformed or be caught by surprise by potentially important information. They are in a better position if they can say: "I knew about that data, assessed it based on the following quality assurance criteria, and decided not to use it for this application." This is especially true for users near the end of long decision processes, such as hazardous site cleanups, lengthy ecological risk assessments, or complex natural resource damage assessments.

For some categories, the editors found no information and inserted the phrase "no information found." This does not necessarily mean that no information exists; it simply means that during our efforts, the editors found none. For many topics, there is probably information "out there" that is not in the Encyclopedia. The more time that passes without encyclopedia updates (none are planned at the moment), the more true this statement will become. Still, the Encyclopedia is unique in that it contains broad ecotoxicology information from more sources than many other reference documents. No updates of this document are currently planned. However, it is hoped that most of the information in the encyclopedia will be useful for some time to come even without updates, just as one can still find information in the 1972 EPA Blue Book [12] that does not seem well summarized anywhere else.

Although the editors of this document have done their best in the limited time available to insure accuracy of quotes or summaries as being "what the original author said," the proposed interagency funding of a bigger project with more elaborate peer review and quality control steps never materialized.

> The bottom line: The editors hope users find this document useful, but don't expect or depend on perfection herein. Neither the U.S. Government nor the National Park Service make any claims that this document is free of mistakes.

The following is one chemical topic entry (one file among 118). Before utilizing this entry, the reader is strongly encouraged to read the README file (in this subdirectory) for an introduction, an explanation of how to use this document in general, an explanation of how to search for power key section headings, an explanation of the organization of each entry, an information quality discussion, a discussion of copyright issues, and a listing of other entries (other topics) covered.

See the separate file entitled REFERENC for the identity of numbered references in brackets.

HOW TO CITE THIS DOCUMENT: As mentioned above, for critical applications it is better to obtain and cite the original publication after first verifying various data quality assurance concerns. For more routine applications, this document may be cited as:

> **Irwin, R.J., M. VanMouwerik, L. Stevens, M.D. Seese**, and **W. Basham.** 1997. Environmental Contaminants Encyclopedia. National Park Service, Water Resources Division, Fort Collins, Colorado. Distributed within the Federal Government as an Electronic Document (Projected public availability

on the internet or NTIS: 1998).

Trichloroethylene (Trichloroethene, TCE, CAS number 79-01-6)

Brief Introduction:

Cautionary note: Although TCE is often used as an abbreviation/synonym for trichloroethylene, the reader is cautioned that TCE has also been used in referencing other common hazardous substances (1,1,1-Trichloroethane, for example). So when someone is referencing "TCE," check the CAS number and other information to determine "which one."

Br.Class: General Introduction and Classification Information:

Trichloroethylene (TCE) is a degreaser and industrial solvent, and is also listed as a carcinogenic priority pollutant [446]. TCE is a volatile organic compound (VOC) [868,903]. TCE is an unsaturated chlorinated aliphatic [601]. This compound is considered a purgeable halocarbon [1010].

One of the most common groundwater pollutants is trichloroethylene (TCE). TCE was once used in abundance for dry cleaning and as a degreasing agent but now banned [1023]. Washington alone has about 10,000 sites contaminated with TCE, according to the state's Department of Ecology [1023].

TCE is a non-flammable, colorless liquid at room temperature with a somewhat sweet odor similar to ether or chloroform, and a sweet, burning taste. TCE is a man-made chemical that does not occur naturally in the environment. Other than its main use as a solvent to remove grease from metal parts, it is also used in other ways and is used to make other chemicals. Trichloroethylene can also be found in some household products, including typewriter correction fluid, paint removers, adhesives, and spot removers [937].

By far the biggest source of trichloroethylene in the environment is evaporation from factories that use it to remove grease from metals. TCE can also enter the air and water when it is disposed of at chemical waste sites [937].

TCE is a toxic pollutant designated pursuant to section 307(a)(1) of the Clean Water Act and is subject to effluent limitations (40 CFR 401.15, 7/1/91) [609].

TCE is designated as a hazardous substance under section 311(b)(2)(A) of the Federal Water Pollution Control Act and further regulated by the Clean Water Act Amendments of 1977 and 1978. These regulations apply to discharges of this substance (40 CFR 116.4, 7/1/91) [609].

Br.Haz: General Hazard/Toxicity Summary:

Potential Hazards to Fish, Wildlife, Invertebrates, Plants, and other Non-Human Biota:

There has been more publicity and attention given to this VOC as a potential hazard to humans than to fish or wildlife; thus there is more literature related to humans and the information found on other species is comparatively sparse compared to the more detailed human health literature. The imbalance in favor of human effects information (and information on human surrogates: rats and mice), as reflected in the sections below, will hopefully be corrected in the future as more ecological effects information becomes available.

Effects of this volatile solvent to non-human biota would often result from: A) high concentrations immediately after a spill (before the compound has volatilized into the atmosphere) or B) the indirect impacts of contaminated groundwater. For example, if highly polluted groundwater water comes into surface or cave waters from springs or seeps, local effects may occur in the mixing zone where the groundwater enters surface water.

Fathead minnows impacted by TCE, 31 days old, lost schooling behavior, swam in a corkscrew/spiral pattern near the surface, were hyperactive and hemorrhaging. Equilibrium loss was not observed prior to death (Geiger D.L., Poirier S.H., Brooke L.T., Call D.J., eds, Acute Toxicities of Organic Chemicals to Fathead Minnows, Pimephales promelas, Vol. II. Superior,Wisconsin: University of Wisconsin-Superior, 1985. 33) [609].

Potential Hazards to Humans:

One problem with trichloroethylene (TCE) in groundwater, and potentially other mediums, is that some of it can eventually break down into other hazardous substances. Therefore, groundwater which has been polluted with TCE, once the TCE concentrations seem to be approaching acceptably low concentrations, often still needs to be checked for hazardous or toxic breakdown products. Major products of biodegradation of TCE in groundwater include dichloroethylene, chloromethane, and vinyl chloride [601,937].

Some of the effects of TCE may actually be caused by other compounds which contaminate TCE or by breakdown products of TCE (see sections on fate, Associated Chemicals, Forms, and Interactions below). In addition to the well know vinyl chloride example:

1) Some mutagenic effects attributed to TCE may be due to epoxy stabilizers sometimes present in trichloroethylene (American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH:American Conference of Governmental Industrial Hygienists, 1986. 596) [609], and

2) Trichloroethylene breakdown products dichloroacetylene, dichloroacetic acid (DCA), trichloroacetic acid (TCA), chloral hydrate, and 2-chloroacetaldehyde, have been shown to be toxic to animals and are probably toxic to humans [937].

People who breathe moderate levels of trichloroethylene may have headaches or dizziness. It is possible that some people who breathe high levels of trichloroethylene may develop damage to some of the nerves in the face. Humans have reported health effects when exposed to the level of trichloroethylene at which its odor is noticeable. Effects have also occurred at much higher levels. Animals that were exposed to moderate levels of trichloroethylene had enlarged livers, and high-level exposure caused liver and kidney damage. However, it is not known if these changes would occur in people who breathe air or drink water containing trichloroethylene [937].

Trichloroethanol, a TCE metabolite, has a pronounced depressant effect on the central nervous system Adverse psychological and behavioral abnormalities in humans have been reported in industrial overexposures and include symptoms of headache, fatigue, lightheadedness, depression, insomnia, irritability, and confusion [609]..

Cranial and peripheral neuropathies have been associated with industrial and medical use (Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology -Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 992) [609].

The Canadian government (1993) has concluded that trichloroethylene is not ordinarily (exceptions might be spills or other direct releases) entering the Canadian environment in concentrations that might be expected to cause adverse effects to aquatic biota or to terrestrial wildlife, or to contribute to the depletion of stratospheric ozone; however, contamination of groundwater was thought to be potentially significant [601].

High levels of exposure are possible for workers in degreasing plants due to inhalation of vapors or adsorption through the skin. Lower inhalation exposure is possible in persons living near degreasing plants or at spill sites. Broad population exposure to low levels from inhalation of contaminated ambient air and ingestion of contaminated drinking water is possible [609].

Presence of metabolites in urine is used as a biomarker of exposure [937] (see also Associated Chemicals section below).

Several comprehensive reports on the hazards of tetrachloroethylene are available. EPA has a free and informative (several page) health advisory on this compound, available through the Office of Drinking Water, EPA, Washington, D.C. or through NTIS. A comprehensive toxicological profile for trichloroethylene, especially as it relates to human health, is available from ATSDR [937]. Due to lack of time, important highlights from this ATSDR document and from the Environment Canada report have not yet been completely incorporated into this entry. Also, Environment Canada has prepared the comprehensive Priority Substances List Assessment Report for trichloroethylene [601].

However, since there is so much information available related to human health, much of the information summarized below is taken from various government summary sources such as the Hazardous Substances Data Bank [609], EPA IRIS database [893], and the ATSDR Human Toxicology Profile [937].

Br.Car: Brief Summary of Carcinogenicity/Cancer Information:

EPA 1996 IRIS database information [893]:

The carcinogen assessment summary for this substance has been withdrawn following further review. A new carcinogen summary is in preparation

(1996) by the CRAVE Work Group.

Considered a carcinogen for EPA modeling (RBC, PRG) calculation purposes [868,903].

Trichloroethylene has been listed by EPA as a class B2 carcinogen, which means that there is sufficient evidence to be classed as an animal carcinogen [446].

Inadequate evidence of carcinogenicity in humans. Limited evidence of carcinogenicity in animals. OVERALL EVALUATION: Group 3: The agent is not classifiable as to its carcinogenicity to humans (IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT., Multivolume work, p. S7 73, 1987) [609].

Major consideration must be given to cumulative effects of this compound. In long-term feeding studies carried out by the national cancer institute in 1976. Mice (both sexes, at both low and high dose levels) experienced a highly significant increase in hepatocellular carcinomas (Doull, J., C.D. Klaassen, and M. D. Amdur, eds., Casarett and Doull's Toxicology. 2nd ed. New York: Macmillan Publishing Co., 1980. 475) [609].

This compound often makes the news related to groundwater pollution and potential cancer risks. For example:

> Electronic News Media Report [Greenwire: February 21, 1997, presented for information purposes, neither the accuracy nor the value of this report has been verified]:
>
> > MASSACHUSETTS: HIGH CANCER RATE LINKED TO LAB Residents of one section of Natick, MA, experienced more than twice the expected rate of an "often-fatal" cancer from 1982 to 1990, according to state records released this week. Nine people within 1.5 miles of the US Army Soldier Systems Command contracted pancreatic cancer during that time period. Marco Kaltofen, a local chemist and co-chair of an advisory committee monitoring the cleanup of the federal Superfund site at the Army lab, has raised concerns that carcinogens from the lab could have reached groundwater and contributed to the high incidence of cancer. Kaltofen: "There may be other sources, but you'd be a fool to ignore the Army labs." Locals think the two chemicals -- trichloroethylene and tetrachloroethane -- may have penetrated a well field in the Springvale

area. The town is currently completing a $4 million treatment system for the Springvale wells. But state Dept. of Public Health officials said the cause of the pancreatic cancer could not be pinpointed. The Springvale wells serve all of Natick, not just the area near the lab, and other sources of contamination are possible, they said. Also, the levels of contamination in the wells near the lab did not regularly exceed state drinking-water standards, they said (Scott Allen, BOSTON GLOBE, 2/20).

Br.Dev: Brief Summary of Developmental, Reproductive, Endocrine, and Genotoxicity Information:

No conclusive studies have been encountered that clearly indicate teratogenic effects in humans [937]. There are anecdotal human reports, but no conclusive animal data. Thus, developmental effects may be a concern for some persons exposed to trichloroethylene [937].

Trichloroethylene was neither embryotoxic nor teratogenic in Sprague-Dawley rats and Swiss Webster mice inhaling trichloroethylene. These results have been confirmed in two other studies in female rats exposed in one case to 500 ppm and in other to 1800 ppm. Trichloroethylene was found to be weakly mutagenic in Escherichia coli in the presence of a metabolizing system or in extensive studies in Drosophila. Some of the positive effects may be due to epoxy compounds used as stabilizers. Positive effects in some studies may be due to epoxy stabilizers sometimes present in trichloroethylene (American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH:American Conference of Governmental Industrial Hygienists, 1986. 596) [609].

Humans exposed to trichloroethylene in the drinking water in certain areas of the country have not shown adverse reproductive effects [937]. There is no evidence that exposure to trichloroethylene has caused adverse reproductive effects in humans, and the biological significance of effects in animals is unknown because reproductive outcome was not tested [937].

Sperm exam from mice exposed to 0.3% for 4 hr daily for 5 days revealed increased abnormalities after 28 days (Shepard, T.H. Catalog of Teratogenic Agents. 5th ed. Baltimore, MD: The Johns Hopkins University Press, 1986. 572) [609].

Data regarding the genotoxicity of trichloroethylene suggest that it is a very weak, indirect mutagen [937].

Mutagenic potential of TCE assessed in vitro by microbial assay using histidine-dependent strains of salmonella typhimurium, ta1535 & ta100. Results for trichloroethylene were equivocal (Baden JM et al; Br J Anaesth 51 (5): 417-21, 1979) [609].

Mutagenicity: Mutation Research 86: 355 (1981). Mouse in vivo somatic mutation assay (spot test) - coat color mutants: positive. (GENE-TOX Program: Current Status of Bioassay in Genetic Toxicology. U.S. Environmental Protection Agency, Washington, DC. Office of Toxic Substances and Pesticides, For program information, contact Environmental Mutagen Information Center, Oak Ridge National Laboratory, Post Office Box Y, Oak Ridge, Tennessee 37830. Telephone 615 574-7871) [609].

See also: W.Human section below.

Br.Fate: Brief Summary of Key Bioconcentration, Fate, Transport, Persistence, Pathway, and Chemical/Physical Information:

Trichloroethylene (TCE) evaporates easily but can stay in the soil and in groundwater. Once it is in the air it will be broken down within a week. When trichloroethylene is broken down in the air, phosgene, a lung irritant, can be formed. Trichloroethylene can break down under certain conditions in the workplace as well as in the body into dichloroacetylene, dichloroacetic acid (DCA), trichloroacetic acid (TCA), chloral hydrate, and 2-chloroacetaldehyde [937].

Once trichloroethylene is in water, much will evaporate into the air; again, about half will break down within a week. It will take days to weeks to break down in surface water; in groundwater the breakdown is much slower because of the much slower evaporation rate. Very little breaks down in the soil, and it can pass through the soil into water underground [937].

TCE does not build up in fish, but it has been found at low levels in them. TCE is not likely to build up in the human body [937].

One problem with TCE in groundwater and potentially other mediums is that some of it can eventually break down into other hazardous substances. Major products of biodegradation of TCE in groundwater include dichloroethylene, chloromethane, and vinyl chloride [601]. The common progression is tetrachloroethylene to trichloroethylene to dichloroethylene to vinyl chloride

(Mario Fernandez, Jr., USGS, personal communication).

Dense liquids that are fairly insoluble in water, such as TCE, are difficult to clean out of groundwater using pump and treat techniques; using pump and treat may not result in cleanups to drinking water MCL levels even if treated for 50 to 1,000 years (Science News, 7-16-94, page 47).

Synonyms/Substance Identification:

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TCE [617]
1,1,2-TRICHLOROETHYLENE [609]
1-CHLORO-2,2-DICHLOROETHYLENE [609]
ACETYLENE TRICHLORIDE [609]
ETHENE, TRICHLORO- [609]
ETHINYL TRICHLORIDE [609]
ETHYLENE TRICHLORIDE [609]
ETHYLENE, TRICHLORO- [609]
TRI [609]
TRICHLORETHYLENE [609]
Trichloroethene [609]
Trichlorethene (French) [609]
Trichlorethylene, tri (French) [609]
EPA Pesticide Chemical Code 081202 [609]
NSC 389 [609]
ALGYLEN [609]
ANAMENTH [609]
BENZINOL [609]
CECOLENE [609]
CHLORILEN [609]
DENSINFLUAT [609]
NCI-C04546 [609]
NIALK [609]
PERM-A-CHLOR [609]
PETZINOL [609]
PHILEX [609]
THRETHYLEN [609]
THRETHYLENE [609]
TRETHYLENE [609]
TRIKLONE [609]
TRILENE [609]
TRIMAR [609]
VESTROL [609]
Tricloretene (Italian) [609]
Tricloroetilene (Italian) [609]
Trielina (Italian) [609]

AI3-00052 [609]
1,1-Dichloro-2-chloroethylene [609]
FLOCK FLIP [609]
FLUATE [609]
GERMALGENE [609]
LANADIN [609]
LETHURIN [609]
NARCOGEN [609]
NARKOSOID [609]
TRI-CLENE [609]
TRI-PLUS [609]
TRIASOL [609]
TRICHLORAN [609]
TRICHLOREN [609]
TRICLENE [609]
Trichloraethen (German) [609]
Trichloraethylen, tri (German) [609]
FLECK-FLIP [609]
Caswell No 876 [609]
Trielin [609]
Chlorylea, Chorylen, CirCosolv, Crawhaspol, Dow-Tri, Dukeron, Per-A-Clor, Triad, Trial, TRI-Plus M, Vitran [609]

Molecular Formula:

C2-H-Cl3 [609]

Associated Chemicals or Topics (Includes Transformation Products):

See also individual entries:

Tetrachloroethylene
Dichloroethylene, 1,1-
Vinyl Chloride

When trichloroethylene is broken down in the air, phosgene, a lung irritant, can be formed [937].

Trichloroethylene can break down under certain conditions in the workplace as well as in the body into dichloroacetylene, dichloroacetic acid (DCA), trichloroacetic acid (TCA), chloral hydrate, and 2-chloroacetaldehyde [937].

Metabolism/Metabolites [609]:

> Excretion of metabolites has been stated to amount to 56% of trichloroethylene inhaled-7-27% trichloroacetic acid, 22.2-22.5% Trichloroethanol, free or conjugated, 22.5-45.5% Urochloralic acid and small amount of monochloroacetic acid and chloroform. ... [Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 194].

Rats excrete 5-7 times more trichloroethanol than trichloroacetic acid after exposure to trichloroethylene. [National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 777].

Metabolism of TCE proceeded through formation of a complex with oxygenated cytochrome p450 which, by rearrangement, can lead to: (a) suicidal heme destruction; (b) formation of chloral, which could be reduced to trichloroethanol and conjugated to form a glucuronide. Rats fed for 3 weeks on an isocaloric diet deficient in carbohydrate (sucrose) had an increased capacity (2-1/2-fold) to metabolize trichloroethylene. [Nakajima T et al; Biochem Pharmacol 31: 1005-11 (1982) as cited in USPEA; Health Assessment Document: Trichloroethylene (Draft) p.4-39 (1983) EPA-600/8-82-006B].

In vitro addition of TCE to incubation mixture decr metab of ethylmorphine & hexobarbital by hepatic microsomes in rats. Inhibition of hexobarbital metab was competitive. Repeated admin to rats decr microsomal cytochrome p450; increased liver/body wt ratio, microsomal proteins, nadph-cytochrome c reductase activity, aniline hydroxylase activity. [PESSAYRE D ET AL; TOXICOL APPL PHARMACOL 49 (2): 355-64 (1979)].

The metabolism of TCE in rats involves oxidation by the liver /SRP: post-mitochondrial supernatant/ mixed function oxidase system to an epoxide intermediate, which binds covalantly to proteins and causes centrilobular damage in the liver. ... [Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-165].

Impurities [609]:

Tetrachloroethane is a contaminant in commercial trichloroethylene. [Arena, J.M. and Drew, R.H. (eds.) Poisoning-Toxicology, Symptoms, Treatments. 5th ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 257].

Acidity (as hydrochloric acid), 0.0005% max; alkalinity (as sodium hydroxide), 0.001% max; residue on evaporation, 0.005% max; antioxidants, such as amine (0.001-0.01% or more) or combinations of epoxides such as epichlorohydrin & esters (0.2-2% total) [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 547 (1979)].

Impurities found in commercial trichloroethylene products include/: carbon tetrachloride, chloroform, 1,2-dichloroethane, trans 1,2-dichloroethylene, cis 1,2-dichloroethylene, pentachloroethane, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, bromodichloroethylene, and benzene. /From table/ [WHO; Environ Health Criteria 50: Trichloroethylene p.21 (1985)].

Water Data Interpretation, Concentrations and Toxicity (All Water Data Subsections Start with "W."):

W.Low (Water Concentrations Considered Low):

Open ocean concentrations in the Gulf of Mexico are less than 0.001 ppb [937]..

W.High (Water Concentrations Considered High):

Highest levels in groundwater in an EPA survey of drinking water systems was 130 ppb [937]..

Phytoremediation: Fortunately, poplar trees appear to have a fondness for TCE [1023]. Moreover, their roots can reach depths of 40 to 50 feet, making them particularly well suited for cleaning groundwater [1023]. With funding from the manufacturing company Occidental Chemical, Milton T. Gordon of the University of Washington in Seattle and his colleagues last year began growing 18 poplars in large, sealed containers into which they pump water containing TCE concentrations of 50 to 70 ppm [1023]. The trees are removing 95 percent of the chemical [1023]. Most contaminated groundwater has TCE concentrations below 25 ppm [1023]. Reseachers are also using cottowood trees for bioremediation of groundwater plumes of TCE (see Tis.Misc. section for details).

W.Typical (Water Concentrations Considered Typical):

In Canada mean concentrations are more than 10 times less than effects levels [601].

Information from HSDB [609]:

SURFACE WATER: 1-24 ppb industrial rivers in US, with Lake Erie - 188 ppb, 88 of 204 samples pos(1); third most frequently detected compound in Ohio River - 2427 of 4972 samples pos, 86% 0.1-1.0 ppb(2); Zurich, Switzerland lake surface - 38 ppb, 30 m depth - 65 ppb(3). USEPA STORET database, 9,295 data points, 28.0% pos, 0.10 ppb median(4). [(1) Ewing BB et al; Monitoring to Detect

Previously Unrecognized Pollutants in Surface Waters USEPA-560/6-77-015 p. 74 (1977) (2) Ohio River Valley Water Sanit Comm 190-81 Assessment of Water Quality Conditions (1982) (3) Grob K, Grob G; J Chromatogr 90: 303-13 (1974) (4) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985)].

DRINKING WATER: 28 of 113 US public water supplies pos, mean 2.1 ppb(1); finished groundwater mean 6.76 ppb, range 0.11-53.0 ppb in 36% of 25 US cities(2). Love Canal, Niagara Falls, NY 7 of 9 samples pos, 10-250 parts/trillion(3); finished groundwater, 466 random samples, 6.4% pos, 1 ppb median concn, 78 ppb max concn(4). State data , 2894 samples, 28.0% pos, trace to 35,000 ppb; US National Screening Program, 142 samples, 25.4% pos, trace to 53 ppb; Community Water Supply Survey, 452 samples, 3.3% pos, 0.5-210 ppb(5). [(1) Brass HJ et al; Drinking Water Qual Enhancement Source Prot pp. 393-416 (1977) (2) Council on Environmental Quality Contamination of Groundwater by Toxic Organic Chemicals pp. 26-34 (1980) (3) Barkley J et al; Biomed Mass Spectrom 7: 139-47 (1980) (4) Cotruvo JA; Sci Total Environ 47: 7-26 (1985) (5) Cotruvo JA et al; pp. 511-30 In: Organic Carcinogens in Drinking Water (1986)].

GROUNDWATER: Most frequently detected and in highest concentration, 28% of wells in 8 states sample pos max conc reported 35000 ppb(2); 38.5% of 13 US cities pos mean 29.72 ppb range 0.2-125 ppb(1). NJ, 670 wells, 1.8% and 4.0% of wells had concn >100 ppb and >10 ppb, respectively(3). Groundwater in the Netherlands 1976-78, 232 pumping stations, 67% pos (>0.01 ppb)(4). [(1) Council on Environmental Quality Contamination of Groundwater by Toxic Organic Chemicals pp. 26-34 (1980) (2) Dyksen JE, Hess AF III; J Amer Water Work Assoc 394-403 (1982) (3) Wilson JT, Wilson BH; ApplEnviron Microbial 49: 243-3 (1985) (4) Zoeteman BCJ et al; Sci Total Environ 21: 187-202 (1981)].

MARINE: Average 0.3 ppb, max 3.6 ppb(1). [(1) Dyksen JE, Hess AF III; J Amer Water Work Assoc 394-403 (1982)].

RAIN/SNOW: La Jolla, CA 5 parts/trillion, industrial area in england 150 parts/trillion(1). Portland, OR, Feb-Apr 1984, concn (parts/trillion), 7 rain events, 100% pos, 0.78-16, 5.6 avg(2). SNOW: Southern California 30 parts/trillion, central california <1.5 parts/trillion, Alaska 39 parts/trillion(1). [(1) SU C, Goldberg ED; Mar Pollut Transfer 1976: 353-74 (1976) (2) Ligocki MP et al; Atmos Environ 19: 1609-17 (1985)].

Effluents Concentrations [609]:

Detected not quantified in wastewater in vicinity of a specialty chemicals plant(1). Industries with mean concentrations greater than 75 ppb, paint and ink formulation, electrical/electronic components, rubber processing mean range, 7-530 ppb, max range 3-1600 ppb(2). USEPA STORET database, 1,480 data points, 19.6% pos, 5.0 ppb median(3). Groundwater at 178 cercla hazardous waste disposal sites, 51.3% pos(4). MN municipal solid waste landfills, leachates, 6 sites, 83.3% pos, 0.7-125 ppb, contaminated groundwater (by inorganic indices), 13 sites, 69.2% pos, 0.2-144 ppb, other groundwater (apparently not contaminated as indicated by inorganic indices), 7 sites, 28.6% pos, 0.2-6.8 ppb(5). [(1) Hites RA et al; ACS Symp Ser 94: 63-90 (1979) (2) USEPA; Treatability Manual pp. I.12.23-3 USEPA-600/2-82-001A (1981) (3) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985) (4) Plumb RHJr; Groundwater Monit Rev 7: 94-100 (1987) (5) Sabel GV, Clark TP; Waste Manag Res 2: 119-30 (1984)].

W.Concern Levels, Water Quality Criteria, LC50 Values, Water Quality Standards, Screening Levels, Dose/Response Data, and Other Water Benchmarks:

W.General (General Water Quality Standards, Criteria, and Benchmarks Related to Protection of Aquatic Biota in General; Includes Water Concentrations Versus Mixed or General Aquatic Biota):

EPA 1996 IRIS database information [893]:

Ambient Water Quality Criteria for Aquatic Organisms:

Acute Freshwater: 4.5E+4 ug/L LEC [893].

Older value was the same: Freshwater Acute Criteria: Insufficient data to develop criteria. Lowest Observed Effect Level: 45,000 ug/L [446].

Chronic Freshwater: 2.19E+4 ug/L LEC [893].

Older value was the same: Freshwater Chronic Criteria: Insufficient data to develop criteria. Lowest Observed Effect Level: 21,900 ug/L [446].

Acute Marine: 2.0E+3 ug/L LEC [893].

Chronic Marine: None Given [893].

Reference: 45 FR 79318 (11/28/80); Quality Criteria for Water, [893].

Contact: Criteria and Standards Division / OWRS / (202)260-1315 [893].

Discussion: The values that are indicated as "LEC" are not criteria, but are the lowest effect levels found in the literature. LECs are given when the minimum data required to derive water quality criteria are not available. [893].

Oak Ridge National Lab, 1994: Ecological Risk Assessment Freshwater Screening Benchmarks for concentrations of contaminants in water [649]. To be considered unlikely to represent an ecological risk, field concentrations should be below all of the following benchmarks [649]:

For CAS 79-01-6, TRICHLOROETHYLENE the benchmarks in ug/L are [649]:

NATIONAL AMBIENT WATER QUALITY CRITERION - ACUTE: No information found

NATIONAL AMBIENT WATER QUALITY CRITERION - CHRONIC: No information found.

SECONDARY ACUTE VALUE: 4350

SECONDARY CHRONIC VALUE: 465

LOWEST CHRONIC VALUE - FISH: 14,867

ESTIMATED LOWEST CHRONIC VALUE - DAPHNIDS: 7257

LOWEST CHRONIC VALUE - NON-DAPHNID INVERTEBRATES: No information found.

LOWEST CHRONIC VALUE - AQUATIC PLANTS: No information found.

LOWEST TEST EC20 - FISH: 5758

LOWEST TEST EC20 - DAPHNIDS: No information found.

SENSITIVE SPECIES TEST EC20: No information found.

POPULATION EC20: 232

Canadian Interim Remediation Criteria for Water for Freshwater Aquatic Life: 20 ug/L [656].

State Water Quality Standards [937]:

Many states have water standards of 5 ug/L; New Jersey's standard is 1 ug/L, New Hampshire's standard is 2.8 ug/L, and Florida's is 3 ug/L [937].

The Netherlands' Harmonized (between media) Maximum Permissible Concentration (MPC) for this compound in water is 2400 ug/L [655].

Note: Harmonization takes into account whether or not the MPC in one media (such as soil) would lead to exceeding the MPC in another media (such as air, water, or sediment) [655].

The Netherlands' Harmonized (between media) Negligible Concentration (NC) for this compound in water is 1% of the MPC, or 24 ug/L [655].

W.Plants (Water Concentrations vs. Plants):

Most adverse effects levels in algae and bacteria are above 1000 ug/L [601].

Information from HSDB [609]:

Toxicity Threshold (Cell Multiplication Inhibition Test) Scenedesmus quadricauda(green algae) >1000 mg/l /Time not specified, conditions of bioassay not specified/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135].

Toxicity Threshold (Cell Multiplication Inhibition Test) Microcystis aeruginosa (algae) 63 mg/l /Time not specified, conditions of bioassay not specified/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1134].

W.Invertebrates (Water Concentrations vs. Invertebrates):

Most adverse effects levels in aquatic invertebrates and bacteria are above 1000 ug/L [601].

LC50 for Daphnia cucullata (water flea) was 56 mg/L for a 48-hr exposure [998].

LC50s for Daphnia magna (water flea) was between 18 and 100 mg/L for a 48-hr exposure, with most values around 50 mg/L [998].

Information from HSDB [609]:

> LC50 Grass shrimp 2 mg/l/96 hr. /Conditions of bioassay not specified/ [Borthwick PW; Results of Toxicity Tests with Fishes and Macroinvertebrates. USEPA, Envir Research Lab (1977)].
>
> Toxicity Threshold (Cell Multiplication Inhibition Test) Entosiphon sulcatum (protozoa) 1200 mg/l /Time not specified, conditions of bioassay not specified/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135].
>
> Toxicity Threshold (Cell Multiplication Inhibition Test) Uronema parduczi Chatton-Lwoff (protozoa) >960 mg/l /Time not specified, conditions of bioassay not specified/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135].
>
> Toxicity Threshold (Cell Multiplication Inhibition Test) Pseudomonas putida (bacteria) 65 mg/l [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1134].

W.Fish (Water Concentrations vs. Fish):

Most adverse effects levels in fish are above 10 ug/L [601].

The lowest-observed-effects-concentration (LOEC) for death in Jordanella floridae (flagfish) is 11 mg/L for a 10-day exposure, and 14.8 for a 28-day exposure [998].

LC50s for Oryzias latipes (medaka, high-eyes) is 440 and 730 mg/L for a 24-hr exposure, and as low as 1.9 mg/L for a 48-hr exposure [998].

Information from HSDB [609]:

> LC50 Sheepshead minnow 20 mg/l/96 hr. /Conditions of bioassay not specified/ [Borthwick PW; Results of Toxicity Tests with Fish and Macroinvertebrates. USEPA Environmental Research Laboratory (1977)].
>
> LC50 Bluegill sunfish 44,700 ug/l/96 hr. /Static bioassay/ [USEPA; In-Depth Studies on Health and Envir Impacts of Selected Water Poll. Contract No. 68-01-4646 (1978) as cited in Ambient Water Quality Document: Trichloroethylene p.B-2 (1980) EPA-440/5/80-007].
>
> LC50 Pimephales promelas (fathead minnow) 40.7 mg/l/96 hr (95% confidence limits 31.4-71.8 mg/l) /Flow-through test/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135].
>
> LC50 Pimephales promelas (fathead minnow) 66.8 mg/l/96 hr (95% confidence limits 59.6-74.7 mg/l) /Static test/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135].
>
> EC10 Pimephales promelas (fathead minnow) 15.2 mg/l/24 hr; 16.9 mg/l/48 hr; 15.5 mg/l/72 hr; 13.7 mg/l/96 hr; Toxic effect for all concentrations specified: loss of equilibrium. /Flow-through bioassay/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135].
>
> EC50 Pimephales promelas (fathead minnow) 23.0 mg/l/24 hr; 22.7 mg/l/48 hr; 22.2 mg/l/72 hr; 21.9 mg/l/96 hr; Toxic effect for all concentrations specified: loss of equilibrium. /Flow-through bioassay/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135].

EC90 Pimephales promelas (fathead minnow) 36.2 mg/l/24 hr; 30.6 mg/l/48 hr; 31.8 mg/l/72 hr; 34.9 mg/l/96 hr; Toxic effect for all concentrations specified: loss of equilibrium. /Flow-through bioassay/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135].

W.Wildlife (Water Concentrations vs. Wildlife or Domestic Animals):

Oak Ridge National Lab, 1994: Risk Assessment Screening Benchmarks for Wildlife derived from No-Observed-Adverse-Effect (NOAEL) levels (see Tis.Wildlife, B) section below for these). To be considered unlikely to represent an ecological risk, water concentrations should be below the following benchmarks for each species present at the site [650]:

For CAS 79-01-6, TRichloroethylene, the benchmarks in ppm are:

SPECIES	WATER CONCENTRATION (ppm)
Mouse (test species)	0.00000
Short-tailed Shrew	4.00000
Little Brown Bat	6.91300
White-footed Mouse	2.58500
Meadow Vole	4.52400
Cottontail Rabbit	2.14400
Mink	2.22300
Red Fox	1.58600
Whitetail Deer	0.88800

Comment: Actually, the number of significant figures for a benchmark value should never be more than one; even if these values have been taken directly from another report, they should be rounded; otherwise the impression is given of a level of accuracy that is simply unwarranted. The uncertainties are too large to justify such a fine distinction (Owen Hoffman, SENES Oak Ridge, Personal Communication, 1997).

Information from HSDB [609]:

Female Sprague-Dawley rats were given

trichloroethylene (TCE) in distilled drinking water at concentrations of 312, 625, and 1250 mg/l. Dams received TCE from 14 days prior to breeding, throughout gestation, and until the pups were weaned at 21 days of age. Control dams received untreated distilled water. Male offspring of experimental and control dams were used to study exploratory behavior either 28, 60, or 90 days of age. Wheel-running, feeding, and drinking behavior tests in rat pups were conducted for 24 hr/day from 55-60 days of age. At 28 days of age, no difference in exploratory activity was seen among treatment groups. At 60 and 90 days of age, rat pups exposed to /SRP: even the lowest concentrations/ of TCE exibited increased levels of exploration. Rats exposed to 1250 mg/l TCE were more active on the wheel than controls or those exposed to 625 mg/l TCE. No significant differences were detected among treatment groups for the levels or timing of feeding or drinking activities. [Taylor DH et al; Sci Total Environ 47: 415-20 (1985)].

LC50 Mexican axolotl (salamander) (3-4 wk after hatching) 48 mg/l/48 hr /Conditions of bioassay not specified/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135].

LC50 Clawed toad (3-4 wk after hatching) 45 mg/l/48 hr /Conditions of bioassay not specified/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135].

W.Human (Drinking Water and Other Human Concern Levels):

EPA 1996 IRIS database information [893]:

Ambient Water Quality Criteria for Human Health

Water & Fish: 2.7E+0 ug/liter [893].

Older references:

Published Criteria for Water and Organisms: 2.7 ug/L [446].

The levels for trichloroethylene through ingestion of contaminated water and contaminated aquatic organisms which may result in incremental increase of cancer risk over the lifetime are estimated at 1X10-5, 1X10-6, and 1X10-7. The corresponding criteria are 27 ug/l, 2.7 ug/l, and 0.27 ug/l, respectively. For consumption of aquatic organisms only, excluding consumption of water, the levels are 807 ug/l, 80.7 ug/l, and 8.07 ug/l, respectively. [609]

IRIS Recalculated (9/90) Criteria for Water and Organisms: 2.7 ug/L [446].

Fish Only: 8.07E+1 ug/liter [893].

Older references:

Published Criteria for Organisms Only: 80.7 ug/L [446].

IRIS Recalculated (9/90) Criteria for Organisms Only: 81 ug/L [446].

Reference: 45 FR 79318 (11/28/80) [893].

Contact: Criteria and Standards Division / OWRS / (202)260-1315 [893].

Discussion: For the maximum protection from the potential carcinogenic properties of this chemical, the ambient water concentration should be zero. However, zero may not be attainable at this time, so the recommended criteria represents a E-6 estimated incremental increase of cancer risk over a lifetime [893].

Maximum Contaminant Level Goal [893]:

Value: 0 mg/L Status/Year: Final 1985
Econ/Tech?: No, does not consider economic or technical feasibility
Reference: 50 FR 46880 (11/13/85) [893].

Contact: Health and Ecological Criteria Division / (202)260-7571 Safe Drinking Water Hotline / (800)426-4791 [893].

Discussion: An MCLG of 0 mg/L for trichloroethylene is proposed based on carcinogenic effects [893,952].

Significant increases in the incidence of liver tumors have been reported in B6C3F1 mice of both sexes. Malignant lymphomas and pulmonary adenocarcinomas were also reported in mice. EPA has classified trichloroethylene in Group B2: sufficient evidence in animals and inadequate evidence in humans. [893].

Maximum Contaminant Level (MCL) [893]:

Value: 0.005 mg/L [893,952].

Status/Year: Final 1987 Econ/Tech?: Yes, does consider economic or technical feasibility Reference: 52 FR 25690 (07/08/87); 56 FR 30266 (07/01/91). [893].

Contact: Drinking Water Standards Division / OGWDW / (202)260-7575 Safe Drinking Water Hotline / (800)426-4791 [893].

Discussion: EPA has set an MCL based on detection limits. [893].

Note: Before citing a concentration as EPA's water quality criteria, it is prudent to make sure you have the latest one. Work on the replacement for the Gold Book [302] was underway in March of 1996, and IRIS is updated monthly [893].

EPA 1995 Region 9 Preliminary remediation goal (PRG) and Region 3 RBC for tap water, 1995: 1.6 ug/L [868,903].

Estimated human lifetime carcinogenic risk: 3.77X10-7 for male and 6.84X10-8 for female /From table, assuming a daily consumption of 1 liter of water containing trichloroethylene in a concn of 1 ug/l/ (National Research Council. Drinking Water & Health. Volume 5. Washington, D.C.: National

Academy Press, 1983. 84) [609].

Cancer slope factor: 1.1E-02 mg/kg-d [893,903,952].

The national revised primary drinking water maximum contaminant level for trichloroethylene for community and non-transient, non-community water systems is 0.005 mg/l. Effective date: 7/30/92. See 56 FR 3593, 1/30/91 (40 CFR 141.61, 7/1/91) [609].

Canadian Interim Remediation Criteria for Water for Drinking Water: 50 ug/L [656].

W.Misc. (Other Non-concentration Water Information):

Reseachers are using cottowood trees and poplar trees for bioremediation of groundwater plumes of TCE (see W.High and Tis.Misc. sections for details).

Sediment Data Interpretation, Concentrations and Toxicity (All Sediment Data Subsections Start with "Sed."):

Sed.Low (Sediment Concentrations Considered Low):

TCE was only found in 6% of 1980-82 Storet Database samples, with median levels less than 5 ppb [937].

Sed.High (Sediment Concentrations Considered High):

Analyses of sewage sludges from 50 publicly owned treatment works by the U.S. Environmental Protection Agency (1985): The mean concentration of trichloroethylene was 9.10 ppm (dry weight) [347].

TCE was as high as 300 ppb near a chemical facility [937].

Sed.Typical (Sediment Concentrations Considered Typical):

Sediment Concentrations [609]:

Not detected in sediment in vicinity of specialty chemicals plant(1). Detected in marine sediments at a max of 9.9 ppb. Liverpool Bay, England(2). USEPA STORET database, 338 data points, 6.0% pos, <5.0 ppb median concn(3). Lake Pontchartrain at Passes, sediment from 3 sites, 66.7% pos, 0.1-0.2 ppb, wet weight(4). [(1) Hites RA et al; ACS Symp Ser 94: 63-90 (1979) (2) Pearson CR, McConnell G; Proc Roy Soc Lond B 189: 305-32 (1975) (3) Staples CA et al; Environ Total Chem 4: 131-42 (1985) (4) Ferrario JB et al; Bull Environ Contam Toxicol 34: 246-55 (1985)].

Sed.Concern Levels, Sediment Quality Criteria, LC50 Values, Sediment Quality Standards, Screening Levels, Dose/Response Data and Other Sediment Benchmarks:

> **Sed.Gen**eral (General Sediment Quality Standards, Criteria, and Benchmarks Related to Protection of Aquatic Biota in General; Includes Sediment Concentrations Versus Mixed or General Aquatic Biota):
>
> > Oak Ridge National Lab, 1994: Risk Assessment Screening Benchmarks for Sediment Concentrations. To be considered unlikely to represent an ecological risk, field concentrations should be below all of the following benchmarks in mg/kg (ppm) dry weight [652]:
> >
> > > For CAS 79-01-6, Trichloroethylene, the bencmark is:
> > >
> > > > ESTIMATED EQUIVALENT SEDIMENT QUALITY CRITERION at 1% Organic Carbon: 1.07 mg/kg dry wt [652].
> > > >
> > > > > Comment: Actually, the number of significant figures for a benchmark value should never be more than one; even if these values have been taken directly from another report, they should be rounded; otherwise the impression is given of a level of accuracy that is simply unwarranted. The uncertainties are too large to justify such a fine distinction (Owen Hoffman, SENES Oak Ridge, Personal Communication, 1997).
> >
> > The Netherlands' Harmonized (between media) Maximum Permissible Concentration (MPC) for this compound in sediments is 13 mg/kg [655].
> >
> > > Note: Harmonization takes into account whether or not the MPC in one media (such as soil) would lead to exceeding the MPC in another media (such as air, water, or sediment) [655].
> >
> > The Netherlands' Harmonized (between media) Negligible Concentration (NC) for this compound in sediments is 1% of the MPC, or 0.13 mg/kg [655].
> >
> > New York freshwater dredging guidance for sediments [761]:
> >
> > > Less than 1 mg/kg dry wt is considered no

appreciable contamination;

One to 100 mg/kg dry wt. considered moderate contamination.

Above 100 mg/kg dry wt. considered high contamination.

Sed.Plants (Sediment Concentrations vs. Plants):

No information found.

Sed.Invertebrates (Sediment Concentrations vs. Invertebrates):

No information found.

Sed.Fish (Sediment Concentrations vs. Fish):

No information found.

Sed.Wildlife (Sediment Concentrations vs. Wildlife or Domestic Animals):

No information found.

Sed.Human (Sediment Concentrations vs. Human):

No information found.

Sed.Misc. (Other Non-concentration Sediment Information):

No information found.

Soil Data Interpretation, Concentrations and Toxicity (All Soil Data Subsections Start with "Soil."):

Soil.Low (Soil Concentrations Considered Low):

No information found.

Soil.High (Soil Concentrations Considered High):

Analyses of sewage sludges from 50 publicly owned treatment works by the U.S. Environmental Protection Agency (1985): The mean concentration of trichloroethylene was 9.10 ppm (dry weight) [347].

Soil.Typical (Soil Concentrations Considered Typical):

No information found.

Soil.Concern Levels, Soil Quality Criteria, LC50 Values, Soil

Quality Standards, Screening Levels, Dose/Response Data and Other Soil Benchmarks:

Soil.General (General Soil Quality Standards, Criteria, and Benchmarks Related to Protection of Soil-dwelling Biota in General; Includes Soil Concentrations Versus Mixed or General Soil-dwelling Biota):

The Netherlands' Harmonized (between media) Maximum Permissible Concentration (MPC) for this compound in soil is 13 mg/kg [655].

Note: Harmonization takes into account whether or not the MPC in one media (such as soil) would lead to exceeding the MPC in another media (such as air, water, or sediment) [655].

The Netherlands' Harmonized (between media) Negligible Concentration (NC) for this compound in soil is 1% of the MPC, or 0.13 mg/kg [655].

Soil.Plants (Soil Concentrations vs. Plants):

No information found.

Soil.Invertebrates (Soil Concentrations vs. Invertebrates):

No information found.

Soil.Wildlife (Soil Concentrations vs. Wildlife or Domestic Animals):

No information found.

Soil.Human (Soil Concentrations vs. Human):

EPA 1996 National Generic Soil Screening Level (SSL) designed to be conservative and protective at the majority of sites in the U.S. but not necessarily protective of all known human exposure pathways, land uses, or ecological threats [952]:

SSL = 58 mg/kg for ingestion pathway [952].

SSL = 5 mg/kg for inhalation pathway [952].

SSL = 0.003 to 0.06 mg/kg for protection from migration to groundwater at 1 to 20 Dilution-Attenuation Factor (DAF) [952].

EPA 1995 Region 9 Preliminary remediation goals (PRGs), 1995 [868]:

Residential Soil: 7.1 mg/kg wet wt.
Industrial Soil: 17 mg/kg wet wt.

NOTE:
1) PRGs focus on the human exposure pathways of ingestion, inhalation of particulates and volatiles, and dermal absorption. Values do not consider impact to groundwater or ecological receptors.
2) Values are based on a non-carcinogenic hazard quotient of one.
3) PRGs for residential and industrial landuses are slightly lower concentrations than EPA Region III RBCs, which consider fewer aspects [903].

EPA 1995 Region 3 Risk based concentration (RBC) to protect from transfers to groundwater:

0.02 mg/Kg dry weight [903].

Soil.Misc. (Other Non-concentration Soil Information):

No information found.

Tissue and Food Concentrations (All Tissue Data Interpretation Subsections Start with "Tis."):

Tis.Plants:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Plants:

No information found.

B) Body Burden Residues in Plants: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

TCE concentrations in plants ranged from 0 to 5 ppb, with some indication of bioconcentration.

See note in Tis.Misc. section below.

Tis.Invertebrates:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Invertebrates:

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Invertebrates:

No information found.

C) Body Burden Residues in Invertebrates: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

Concentrations in clams and oysters from Lake Ponchartrain, Louisiana were from 0.8 to 5.7 ppb [937].

Tis.Fish:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Fish (Includes FDA Action Levels for Fish and Similar Benchmark Levels From Other Countries):

EPA 1995 Region 3 Risk based concentration (RBC) for fish tissue:

0.29 mg/Kg [903].

NOTE: Not sure whether wet or dry weight, depends upon whether default EPA fish consumption is wet or dry, but probably wet (Roy Smith, EPA, personal communication, 1996).

B) Concentrations or Doses of Concern in Food Items Eaten by Fish:

No information found.

C) Body Burden Residues in Fish: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

Fish from U.S. contain 10-100 ppb TCE [937].

Fish/Seafood Concentrations [609]:

Marine Fish, flesh - 0.04-1.1 ppm, liver - 0.66-20.0 ppb, mussels - 50 day exposure 1.37 ppm(1). Lake Pontachartrain at Passes, oysters, 5 samples, 2.2 ppb avg; clams, composite samples from 2 sites, 5.7 and 0.8 ppb(2). [(1) Pearson CR, McConnell G; Proc R Soc Lond B 189: 305-32 (1975) (2) Ferrario JB et al; Bull Environ Contam Toxicol 34: 246-55 (1985)].

Conger conger (eel): gill, gut: 29 ng/g; brain, muscle: 62-70 ng/g. [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand

Reinhold Co., 1983. 1134].

Gaddus morhua (cod): stomach, muscle: 7-8 ng/g; brain, liver: 56-66 ng/g. [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1134].

Pollachius birens (coal fish): muscle: 8 ng/g; alimentary canal: 306 ng/g. [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1134].

Scylliorhinus canicula (dog fish): muscle, gut, brain: 40-41 ng/g; liver: 479 ng/g. [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1134].

Trisopterus luscus (bib): gill: 40 ng/g; muscle, skeletal tissue: 185-187 ng/g. [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1134].

Tis.Wildlife: Terrestrial and Aquatic Wildlife, Domestic Animals and all Birds Whether Aquatic or not:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Wildlife, Domestic Animals, or Birds:

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Wildlife, Birds, or Domestic Animals (Includes LD50 Values Which do not Fit Well into Other Categories, Includes Oral Doses Administered in Laboratory Experiments):

Oak Ridge National Lab, 1994: Risk Assessment Screening Benchmarks for Wildlife derived from No-Observed-Adverse-Effect (NOAEL) levels (mg contaminant per kg body weight per day). To be considered unlikely to represent an ecological risk, wet-weight field concentrations should be below the following (right column) benchmarks for each species present at the site [650]:

For CAS 79-01-6, Trichloroethylene, the bencmarks are:

	NOAEL	FOOD CONCEN-

SPECIES	(mg/kg/day)	TRATION (ppm)
Mouse (test species)	0.70000	0.00000
Short-tailed Shrew	0.88000	1.46700
Little Brown Bat	1.10600	3.31800
White-footed Mouse	0.77500	5.01800
Meadow Vole	0.61700	5.42900
Cottontail Rabbit	0.20700	1.04900
Mink	0.22000	1.60600
Red Fox	0.13400	1.34000
Whitetail Deer	0.05800	1.88800

Comment: Actually, the number of significant figures for a benchmark value should never be more than one; even if these values have been taken directly from another report, they should be rounded; otherwise the impression is given of a level of accuracy that is simply unwarranted. The uncertainties are too large to justify such a fine distinction (Owen Hoffman, SENES Oak Ridge, Personal Communication, 1997).

Information from HSDB [609]:

LD10 Female CD-1 Mouse gavage 1161 mg/kg; male CD-1 mouse gavage 1347 mg/kg. [Tucker AN et al; Toxicol Appl Pharmacol 62 (3): 351-7 (1982)].

LD50 Female CD-1 Mouse gavage 2443 mg/kg; male CD-1 mouse gavage 2402 mg/kg [Tucker AN et al; Toxicol Appl Pharmacol 62 (3): 351-7 (1982)].

LD90 Female CD-1 Mouse gavage 2443 mg/kg; male CD-1 mouse gavage 4253 mg/kg. [Tucker AN et al; Toxicol Appl Pharmacol 62 (3): 351-7 (1982)].

LD100 Female CD-1 Mouse gavage 5500 mg/kg; male CD-1 mouse gavage 6000 mg/kg. [Tucker AN et al; Toxicol Appl Pharmacol 62(3): 351-357 (1982)].

LD50 Dog oral 5680 mg/kg [WHO; Environmental Health Criteria 50; Trichloroethylene p.55 (1985)].

Chronic administration /by gavage/ of 2400 mg/kg per day of trichloroethylene to male B6C3F1 mice, induced localized cell necrosis, enhanced DNA synthesis, and centrilobular hepatocellular swelling. Prolonged exposure (3 weeks), the primary response was dose-related centrilobular hepatocellular swelling and the occurrence of mineralized (calcified) cells. [Stott WT et al; Toxicol Appl Pharm 62: 137-51 (1982) as cited in

USEPA; Health Assessment Document: Trichloroethylene (Draft) p.4-35 (1983) EPA-600/8-82-006B] [609].

C) Body Burden Residues in Wildlife, Birds, or Domestic Animals: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

Trichloroethylene concentrations in sea bird eggs: 23-33 mg/kg. Alca torda (razorbill auk), Uria aalge (guillemot), Rissa tridactyla (Kittiwake). 2.4 mg/kg for Phalacrocrax aristotelis (shag). /Sampling conducted near Liverpool Bay, United Kingdom/ [Pearson CR, McConnell G; Proc R Soc London Ser B 189: 305-22 (1975) as cited in WHO; Environ Health Criteria 50: Trichloroethylene p.37 (1985)] [609]

Tis.Human:

A) Typical Concentrations in Human Food Survey Items:

See also Tis.Fish, C) above.

A 1985 analysis of grain based foods showed the highest TCE concentration (2.4 ppb) in fudge brownie mix [937].

Food Survey Results [609]:

Intermediates grain-based food (1984): 9 varieties, 44.4% pos, 0.77-2.7 ppb, 1.9 ppb (max concn in yellow corn meal; wheat, corn, oats (1984)), 10, 2, and 1 samples, respectively: not detected(1). Table-ready foods: 19 varieties, 47% pos, 1.7-8.0 ppb, 1.5 ppb avg, max concn in plain granola; butter, 7 samples, 100% pos; 1.6-20 ppb, 9.7 ppb avg; margarine, 7 samples, 100% pos, 3.7-980 ppb, 4.3 ppb avg of pos, max concn in Mozzarella cheese(2). Trace detected in extracted edible oils(1). Also detected in meat, beverages, dairy products, fruits and vegetables, oil and fats, range 0.02-60 ug/kg(1). (SRC) [(1) Heikes DL, Hopper ML; J Assoc Off Anal Chem 69: 990-8 (1986) (2) Heikes DL; J Assoc Off Anal Chem 70: 215-26 (1987)].

Concentration of trichloroethylene in foods: Cheshire cheese: 3 mg/kg; English butter: 10 mg/kg; eggs: 0.6 mg/kg; shin of beef: 16 mg/kg; beef fat: 12 mg/kg; pig liver: 22 mg/kg; margarine: 6 mg/kg; olive oil (spanish): 9 mg/kg; cod liver oil: 19 mg/kg; vegetable oil for frying: 7 mg/kg; fruit juices: 5 mg/kg; light beer: 0.7 mg/kg; freeze-dried coffee: 4 mg/kg; tea in bags: 60 mg/kg; Yugoslavian wine: 0.02; potatoes: 3 mg/kg; apples: 5 mg/kg; pears: 5 mg/kg; fresh bread: 7 mg/kg. /From table/ [McConnell G et al; Endeavor 34; 13-8 (1975) as cited in WHO; Environ Health Criteria 50: Trichloroethylene p.39 (1985)].

Trichloroethylene is an indirect food additive for use only as a component of adhesives. [21 CFR 175.105 (4/1/91)].

Milk Concentrations [609]:

Detected in dairy products. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V11 263 (1976)].

Concentration of trichloroethylene in fresh milk: 0.3 mg/kg. /From table/ [McConnell G et al; Endeavor 34; 13-8 (1975) as cited in WHO; Environ Health Criteria 50: Trichloroethylene p.39 (1985)].

B) Concentrations or Doses of Concern in Food Items Eaten by Humans (Includes Allowable Tolerances in Human Food, FDA, State and Standards of Other Countries):

EPA 1995 Region 3 Risk based concentration (RBC) for fish tissue:

0.29 mg/Kg [903].

NOTE: Not sure whether wet or dry weight, depends upon whether default EPA fish consumption is wet or dry, but probably wet (Roy Smith, EPA, personal communication, 1996).

The estimated fatal oral dose in humans is 3-5 ml/kg. The lowest concn produce unconsciousness in adult humans is 16 mg/l (3,000 ppm); the equivalent oral dose is 40-150 ml (Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-165) [609]

Average Daily Intake [609]:

Air Intake: (assume typical concn of 100-500 parts/trillion(4-5)) - 11-33 ug; Water Intake: (assume 2-7 ppb) 2-20 ug; Food Intake - insufficient data(SRC). [(1) Brass HJ et al; Drinking Water Qual Enhancement Source Prot pp. 393-416 (1976) (2) Council of Environmental Quality; Contamination of Groundwater by Toxic Organic Chemicals pp. 26-34 (1980) (4) Singh HB et al; Environ Sci Technol 16: 872-80 (1982) (5) Singh HB et al; Atmos Environ 15: 601-12 (1981)].

C) Body Burden Residues in Humans: Typical, Elevated, or of Concern Related to the Well-being of Humans:

Mother's milk 4 US urban areas, 8 of 8 samples pos(1). Post-mortem wet tissue samples 1-32 ppb(2). Love Canal, Niagara Falls, NY - Breath - trace 4 of 9 samples pos, Blood - 0.09.50 ppb, 6 of 9 samples pos, urine - 40-550 parts/trillion, 9 of 9 samples pos(3). Whole blood specimens from 250 subjects, not detected to 1.5 ppb, 0.4 ppb avg(4). (SRC) [(1) Pellizzari ED et al; Bull Contam Toxicol 28: 322-8 (1982) (2) IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man 11: 263-76 (1976) (3) Barkley J et al; Biomed Mass Spectrom 7: 139-47 (1980) (4) Antoine SR et al; Bull Environ Toxicol 36: 364-71, 1986)] [609].

Therapeutic or normal blood level 0.1-9 mg% (Winek, C.L. Drug and Chemical Blood-Level Data 1985. Pittsburgh, PA: Allied Fischer Scientific, 1985) [609]

Tis.Misc. (Other Tissue Information):

The Air Force and USGS, in late 1996, were beginning a study of bioremediation of a large groundwater plumes of TCE at a Fort Worth, Texas, Air Force Base, using phytoremediation of cottonwood trees. Possibilities include:

1) That the trees may somehow breakdown some of the TCE (perhaps bacteria at the root interface will help in the breakdown?) and,

2) Perhaps that a transfer of some TCE to the atmosphere may occur.

However, as of December, 1996, the roots of the trees had not yet reached the TCE groundwater plume, so definitive results were not available (Sandra Eberts, USGS, and Greg Harvey, US Air Force, Personal Communication, 1996).

Reseachers are also using poplar trees for bioremediation of groundwater plumes of TCE (see W.High section above for details).

Bio.Detail: Detailed Information on Bioconcentration, Biomagnification, or Bioavailability:

The BCF in fish was 17 [937].

The biological half-lives of the urinary metabolites of humans occupationally exposed to trichloroethylene was approx 41 hr (Ikeda M, Imamura T; Int Arch Arbeitsmed 31, 3: 209-24, 1973) [609]

Bioconcentration [609]:

Marine monitoring data only suggest moderate bioconcentration (2-25 times) (1,2). Bioconcentration factors of 17 to 39 have been reported in bluegill sunfish and rainbow trout(3,4).(SRC) [(1) Dickson AG, Riley JP; Marine Pollut Bull 7: 167-9 (1976) (2) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975) (3) Lyman WJ; Handbook of Chemical Property Estimation Methods Ann Arbor Sci, MI p. 5-9 (1981) (4) Barrows ME et al; Dynamics, Exposure, Hazard Assessment Toxic Chem p. 379-92 (1980)]

Interactions:

Information from HSDB [609]:

Disulfiram is said to inhibit the oxidation /of trichloroethylene/ in man to the more toxic trichloroethanol (and thence to trichloroacetic acid) [Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-112].

In vitro, addition of TCE decreases metabolism of ethylmorphine & hexobarbital by rat hepatic microsomes. In vivo, TCE inhibited hexobarbital metabolism in rats. [Pessayre D et al; Toxicol Appl Pharmacol 49 (2): 355-64 (1979)].

Biochemical & toxicological effects of combined exposure to 1,1,1-trichloroethane (500 ppm) & TCE (200 ppm) for 4 days 6 hr daily caused accum of 1,1,1-trichloroethane in perirenal fat. Further exposure on day 5 caused rapid increases in various organ contents of both solvents with depression of brain RNA. [Vainio H et al; Xenobiotica 8 (3): 191-6 (1978)].

Rabbits were given 10 mg/kg doses of caffeine 30 minutes prior to exposure to 6000 ppm (32,280 mg/cu m) of trichloroethylene under dynamic airflow conditions. Epinephrine was infused until arrhythmias occurred after 7.5, 15, 30, 45, and 60 minutes of exposure and 15 and 30 minutes post-exposure. An increase in epinephrine-induced arrhythmias in trichloroethylene-exposed rabbits was observed when the animals were treated with caffeine and challenged with doses of epinephrine as low as 0.5 ug/kg. [White JF, Carlson GP; Fund Appl Toxicol 2: 125-9 (1982) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.5-6 (1983) EPA-600/ 8-82-006B].

Phenobarbital administration to rats or hamsters in vivo increases the oxidation of trichloroethylene. This results in an incr in the conversion of trichloroethylene to trichloroacetaldehyde. [Ikeda M, Imamura T; Int Arch Arbeitsmed 31: 209 (1973) as cited in Ambient Water Quality Criteria Document: Trichloroethylene p.C-10 (1980) EPA 440-5/ 80-007].

Compared to chloral hydrate alone, ingestion of ethanol 30 minutes after chloral hydrate resulted in higher and more prolonged concentrations of plasma trichloroethanol and in lower plasma trichloroacetic acid levels and in urinary trichloroethanol glucuronide. [Sellers EM et al; Metab Clin Pharmacol Ther 13: 37-49 (1972) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.4-37 (1983) EPA-600/8-82-006B].

Disulfiram (1.35 mmol/kg) was administered perorally to rabbits 24 and 6 hr prior to a 1 hr exposure (6000 ppm 32,280 mg/cu m) of trichloroethylene. When challenged with 0.5-3.0 ug/kg epinephrine, disulfiram prevented epinephrine-induced arrhythmias. [Fossa AA et al; Toxicol Appl Pharm 66: 109-17 (1982) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.5-11 (1983) EPA-600/8-82-006B].

Isopropanol and acetone cause enhanced hepatotoxicity with trichloroethylene. [Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 348].

Studies /conducted/ with rats /indicate/ that the effects of trichloroethylene were more pronounced in the animals that were fed a high carbohydrate diet than those on a high protein diet. /Concentration of trichloroethylene not specified/ [Kalashinikova VP et al; Vopr Pitan 6: 43-7 (1974) as cited in WHO; Environ Health Criteria 50: Trichloroethylene p.61 (1985)].

Rats exposed to 37,000, 42,000, and 56,000 mg/cu m of trichloroethylene vapor for two hours exhibited elevated activities of serum glutamic pyruvic transaminase, glutamic oxaloacetic transaminase, and isocitrate dehydrogenase. Hepatotoxicity (indicated by the increased levels of these hepatic enzymes in the serum) was greatly enhanced by pretreatment with 3-methylcholanthrene. [Carlson GP; Res Comm

Chem Pathol Pharmacol 7: 637 (1974) as cited in USEPA; Ambient Water Quality Document: Trichloroethylene p.C-19 (1980) EPA-440/5/80-007].

To elicit the "degreaser's flush," ethanol was administered to seven male volunteers who were repeatedly exposed to trichloroethylene (TCE) vapor. In six exposed subjects, transient vasodilatation of superficial skin vessels occurred after the ingestion of small amounts of ethanol (<0.5 ml/kg body weight). The dermal response reached maximum intensity 30 minutes after its onset and then faded completely within 60 minutes. Two factors appear necessary before the dermal response can be elicited: (1) repeated exposures to TCE and (2) ingestion of alcohol. [Stewart RD et al; Arch Environ Health 29: 1 (1974)].

Uses/Sources:

Major Uses [609]:

In degreasing, in dry cleaning; in mfg org chem & pharmaceuticals [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1517].

In gas purification, as a solvent of sulfur & phosphorus [Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 190].

Refrigerant & heat exchange liquid; diluent in paints & adhesives; textile processing; aerospace operations (flushing liquid oxygen) [Sax, N.I. and R.J. Lewis, Sr., eds., Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 1176].

cleaning solvent, esp in vapor degreasing [SRI].

Chain terminator in prodn of polyvinyl chloride [SRI].

Swelling agent in disperse dyeing of polyesters [SRI].

Agent in removal of basting threads in textile processing [SRI].

Chem int for 1,1,2,2-tetrachloroethyl sulfenyl chloride [SRI].

Solvent in adhesives & paint-stripping formulations [SRI].

Heat transfer medium-eg, in case hardening of metals [SRI].

Solvent base for metal phosphatizing systems [SRI].

Solvent in characterization test for asphalt [SRI].

Entrainer for recovery of formic acid [SRI].

Extraction solvent-eg, for caffeine [SRI].

Used as household cleaner; with trichloroethane it is used in most typewriter correction fluid. /SRP: Former use/ [Arena, J.M. and Drew, R.H. (eds.) Poisoning-Toxicology, Symptoms, Treatments. 5th ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 257].

Used in wool-fabric scouring [Considine. Chemical and process technol encyc 1974 p.1109].

Extractant for spice oleoresins. [WHO; Environ Health Criteria 50: Trichloroethylene p.30 (1985)].

Intermediate in the production of pentachloroethane. [WHO; Environ Health Criteria 50: Trichloroethylene p.30 (1985)].

Carrier solvent for the active ingredients of insecticides, and fungicides. [WHO; Environ Health Criteria 50: Trichloroethylene p.30 (1985)].

Medication (Vet): Inhalation anesthetic. /Former use/ [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1516].

Natural Sources [609]:

Trichloroethylene is not known to occur as a natural product. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 550 (1979)].

Artificial Sources [609]:

Air emissions from metal degreasing plants(1). Wastewater from metal finishing, paint and ink formulation, electrical/electronic components, and rubber processing industries contain trichloroethylene(2). Therefore, environmental releases may occur via wastewater, spills and emissions from its production and use(SRC). [(1) Ewing BB et al; Monitoring to Detect Previously Unrecognized Pollutants in Surface Waters. USEPA-560/6-77-015 p. 74 (1977) (2) USEPA; Treatability Manual pp.I.12.23-1 to I.12-23-5 USEPA-600/2-82-001A (1981)].

Forms/Preparations/Formulations:

Information from HSDB [609]:

Trichloroethylene for medicinal purposes may contain some thymol or ammonium carbonate (not more than 20 mg/100 ml) as stabilizer. Industrial grades ... May contain other stabilizers, such as triethanolamines stearate and cresol. [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1516].

Grades: usp; technical; high purity; electronic; metal degreasing; extraction. [Sax, N.I. and R.J. Lewis, Sr., eds., Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 1176].

Antioxidants are added to trichloroethylene in quantities less than 1% by weight. [Bretherick, L. Handbook of Reactive Chemical Hazards. 3rd ed. Boston, MA: Butterworths, 1985. 218].

Trichloroethylene is available in the USA in high-purity, electronic USP, technical, metal degreasing and extraction grades [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 545 (1979)].

AR, ACS reagent and 98% grade [CHEMCYCLOPEDIA 1987 p.300].

Stabilizers in trichloroethylene formulations include: amyl alcohol, propanol, diethylamine, triethylamine, dipropylamine, diisopropylamine, diethanolamine, morpholine, n-methylmorpholine, aniline, acetone, ethylacetate, borate esters, ethylene oxide, 1,2-propylene oxide, 1,2-epoxybutene, cyclohexene oxide, propylene oxide, butadiene oxide, styrene oxide, pentene oxide, 2,3-epoxy 1-propenol, 3-methoxy-1,2-epoxy propane, stearates, 2-methyl-1,2-epoxypropanol, epoxy cyclopentanol, epichlorohydrin, tetrahydrofuran, tetrahydropyran, 1,4-dioxane, dioxalane, trioxane, alkoxyaldehyde hydrazones, methyl ethyl ketone nitromethanes, nitropropanes, phenol, o-cresol, thymol, p-tert-butylphenol, p-tert-amylphenol, isoeuganol, pyrrole, n-methylpyrrole, n-ethyl pyrrole, (2-pyrryl)-trimethylsilane, glycidyl acetate, isocyanates, and thiazoles. [USEPA; Health Assessment Document: Trichloroethylene (Draft) p.3-2 (1984) EPA-800/8-82-006B].

Commonly used stabilizers found in /commercial trichloroethylene products include/: pentanol-2 triethanolamine, 2,2,4-trimethylpentene-1, and iso-butanol. /From table/ [WHO; Environ Health Criteria 50: Trichloroethylene p.21 (1985)].

Chem.Detail: Detailed Information on Chemical/Physical Properties:

Solubilities [609]:

Sol in chloroform, acetone, alcohol, ether [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-272].

1.100 mg/l water at 25 deg C [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1132].

1.1 to 1.4 g/L in water [601].
Miscible in oil. [Health and Safety Executive Monograph: Trichloroethylene #6 p.2 (1982)].

Vapor Pressure [609]:

19.9 MM HG @ 0 DEG C; 57.8 MM HG @ 20 DEG C [National Research Council. Prudent Practices for Handling Hazardous Chemicals in Laboratories. Washington, DC: National Academy Press, 1981. 149].

Vapor Density [609]:

4.53 /Air=1/ [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1516].

Density/Specific Gravity [609]:

1.4649 @ 20 DEG C/4 DEG C [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1516].

Molecular Weight [609]:

131.40 [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-272].

Henry's Law Constant [609]:

1X10-2 atm-cu m/mole. [Eisenreich SJ et al; Environ Sci Technol 15:30-8 (1981)].

Octanol/Water Partition Coefficient:

log Kow= 2.29 (Hansch, C., A. Leo. Substituent Constants for Correlation Analysis in Chemistry and Biology. New York, NY: John Wiley and Sons, 1979. 174) [609].

Log Kow 2.29 to 2.42 [601].

Other Chemical/Physical Properties [609]:

Oil/water coefficient 900:1 [Waters EM et al; J Toxicol Envir Health 2: 671-707 (1977) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.3-3 (1983) EPA-600/ 8-82-006B].

Olive oil/water partition coefficient 522:1 at 37 deg C. [Sato A, Nakajima T; Arch Envir Health 43: 69-75 (1979) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p. 3-3 (1983) EPA-600/8-82-006B].

Boiling Point [609]:

87 DEG C [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-272].

Melting Point [609]:

-73 DEG C [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-272].

Surface Tension [609]:

29.3 dynes/cm = 0.0293 N/m at 20 deg C [U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.].

Viscosity [609]:

0.00550 poise at 25 deg C [Flick, E.W. Industrial Solvents Handbook. 3rd ed. Park Ridge, NJ: Noyes Publications, 1985. 143].

Color/Form [609]:

CLEAR, COLORLESS, OR BLUE MOBILE LIQUID [Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980. 986].

Odor [609]:

Ethereal odor [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1132].

Chloroform-like odor [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-272].

Sweet odor [Health and Safety Executive Monograph: Trichloroethylene #6 p.3 (1982)].

Fate.Detail: Detailed Information on Fate, Transport, Persistence, and/or Pathways:

Detailed information about the biocatlysis/biodegradation fate of this compound is included on the University of Minnesota Biocatlysis/Biodegradation Database (Available on the interet in July, 1997, www.nmsr.labmesd.umn.edu).

One potentially important aspect of the presence of trichloroethylene is that it can breakdown into vinyl chloride. According to EPA's health advisories (available through the Office of Drinking Water, EPA, Washington, D.C. or through NTIS) on vinyl chloride and dichloroethylene, vinyl chloride is a degradation product of trichloroethylene and tetrachloroethylene in groundwater, with dichloroethylene being an intermediate breakdown product. The common progression is tetrachloroethylene to trichloroethylene to dichloroethylene to vinyl chloride (Mario Fernandez, Jr., USGS, personal communication).

Although some vinyl chloride can result from the breakdown of the above-listed solvents, not 100% of the breakdown route is to vinyl chloride (some other breakdown pathways exist and different resultant breakdown products are sometimes produced, Karl Ford, BLM, personal communication).

Abiotic Degradation [609]:

Trichloroethylene is not hydrolyzed by water under normal conditions(1). It does not adsorb light of less than 290 nm and therefore should not directly photodegrade(1). However, slow (half-life -l0.7 months) photooxidation in water has been noted(2). Trichloroethylene is relatively reactive under smog conditions(3) with 60% degradation in 140 min(4) and 50% degradation in 1 to 3.5 hours(5) reported. Atmospheric residence times based upon reaction with hydroxyl radical is 5 days(6-8) with production of phosgene, dichloroacetyl chloride, and formyl chloride(4,7).(SRC) [(1) Callahan MA et al; Water-Related Environmental Fate of 129 Priority Pollutants - Vol II USEPA-440/4-79-029B (1979) (2) Dilling WL; Environ Sci Tech 9: 833-8 (1975) (3) Yanagihara S et al; Photochemical Reactivities of Hydrocarbons Proc Int Clean Air Congress, 4th pp. 472-7 (1977) (4) Gay BW et al; Environ Sci Tech 10: 58-67 (1976) (5) Dilling WL et al; Environ Sci Tech 10: 351-6 (1976) (6) Chang JS, Kaufman F; J Chem Phys 66: 4989-94 (1977) (7) Cupitt LT; Fate of Toxic and Hazardous Materials in the Air Environment USEPA-600/3-80-084 (1980) (8) Singh HB et al; Atmos Environ 15: 601-12 (1981)].

Soil Adsorption/Mobility [609]:

Low adsorption coefficient (log Koc = 2.0) (1) to a number of soil types (2) indicates ready transport through soil and low potential adsorption to sediments

(SRC). The mobility in soil is confirmed in soil column studies (1) and river bank infiltration studies(3-5). 4-6% of environmental concentrations of trichloroethylene adsorbed to two silty clay loams (Koc = 87 and 150)(6). No adsorption to Ca-saturated montmorillonite and 17% adsorption to Al-saturated montmorillonite was observed(6). (SRC) [(1) Wilson JT et al; J Environ Qual 10: 501-6 (1981) (2) Dilling WL; Environ Sci Technol 9: 833-8 (1975) (3) Sontheimer H; J Amer Water Works Assoc 72: 386-90 (1980) (4) Schwarzenbach RP et al; Environ Sci Technol 17: 472-9 (1983) (5) Zoetman BCJ et al; Chemosphere 9: 231-49 (1980) (6) Rogers RD, McFarlane JC; Environ Monit Assess 1: 155-62 (1981)].

Volatilization from Water/Soil [609]:

High Henry's Law Constant 1X10-2 atm-cu m/mole(1) indicates rapid evaporation from water (3). Half-lives of evaporation have been reported to be on the order of several minutes to hours, depending upon the turbulence(2-3). Field studies also support rapid evaporation from water(4). Relatively high vapor pressure indicates rapid evaporation from near-surface soil and other surfaces. (SRC) [(1) Eisenreich SJ et al; Environ Sci Technol 15: 30-8 (1981) (2) Dilling WL; Environ Sci Technol 9: 833-8 (1975) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods NY: McGraw-Hill pp. 15-25 (1981) (4) Wakeham SG et al; Environ Sci Technol 17: 611-7 (1983)].

Absorption, Distribution and Excretion [609]:

1. TCE can penetrate intact human skin. [Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-165].

2. Placental transmission data: time to appear in fetus--2 min; time to fetal/maternal concn equilibrium--6 min; fetal/maternal concentration ratio--1.0 /From table/ [LaDu, B.N., H.G. Mandel, and E.L. Way. Fundamentals of Drug Metabolism and Disposition. Baltimore: Williams and Wilkins, 1971. 100].

3. A daily exposure level of approximately 100 ppm, only one-third of the retained trichloroethylene (calculated) is excreted as metabolites in the urine during the work day. [Doull, J., C.D. Klaassen, and M. D. Amdur, eds., Casarett and Doull's Toxicology. 2nd ed. New York: Macmillan Publishing Co., 1980. 475].

4. Binding of TCE to liver microsomal proteins of male b6c3 hybrid mice was 46% higher than /binding of/ (14)c-TCE to microsomal proteins from male osborne-mendel rats.

[Banerjee s et al; cancer res 38 (3): 776-80 (1978)].

5. 10 volunteer students were exposed to 250-380 ppm of trichloroethylene for 160 min. Retention amounted to 36%. 16% Of the retained amount was eliminated through respiration after exposure. Trichloroacetic acid excretion in females was 2-3 times more than that in males for the 1st 24 hr after exposure. Twice as much trichloroethanol was excreted in males than in females for the 1st 12 hr. These findings suggest a sex difference in human metabolism of trichloroethylene. [Nomiyama k, nomiyama h; int arch arbeitsmed 28 (1): 37-48 (1971)].

6. The blood concn of trichloroethylene during inhalation and elimination /in humans/ closely parallels alveolar gas concn. Trichloroethylene most rapidly attains equilibrium by passive diffusion into the vessel rich group of tissues (VRG) (brain, heart, kidneys, liver, endocrine and digestive systems), more slowly with lean mass (MG) (muscle and skin) and lastly with adipose tissue (FG). As determined from elimination kinetics following exposure, trichloroethylene distributes from blood into these 3 major compartments at approx rate constants of VRG: 17 hr(-1) (half-life, 2.4 min), MG: 1.7 hr(-1) (t/2, 25 min) and FG: 0.2 hr(-1) (half-life, 3.5 hr). While MG is 50% of the body vol versus 20% for FG, saturation and desaturation proceeds more rapidly from the MG compartment than the FG compartment because of the considerably greater solubility of trichloroethylene in lipids. Thus, variations in trichloroethylene uptake between individuals is influenced first by lean body mass and second by adipose tissue mass. [USEPA; Health Assessment Document: Trichloroethylene (Draft) p.4-5 (1983) EPA-600/8-82-006B].

7. Careful balance studies using GC methodology show, that after single or repeated daily exposures to trichloroethylene concentrations between 50 and 380 ppm, an average of 11% of /absorbed/ trichloroethylene is eliminated unchanged by the lung (half-life= 5 hr), 2% of the dose is eliminated as trichloroethanol by the lung (half-life 10 to 12 hr) and 58% is eliminated as urinary metabolites. The remaining 30% of the dose has been postulated to be metabolized by additional pathways or routes of elimination of one or more unknown metabolites. [USEPA; Health Assessment Document: Trichloroethylene (Draft) p.4-22 (1983) EPA-600/8-82-006B].

8. Trichloroethylene is an uncharged, non-polar, and highly lipophilic compound which can be expected to cross the gastrointestinal mucosa by passive diffusion. [USEPA; Health Assessment Document: Trichloroethylene (Draft) p.4-2 (1983) EPA-600/8-82-006B].

9. The ratio between trichloroethylene exposure and urinary trichloroacetic acid excretion appears to decrease with age. [Grandjean E et al; Br J Ind Med 12: 131 (1955) as cited in USEPA; Ambient Water Quality Criteria Document: Trichloroethylene p.C-10 (1980) EPA 440/5/80-007].

10. Pure trichloroethylene is absorbed through mouse abdominal skin at a rate of 55 nmol/sq cm/min. [Tsuruta H; Ind Health 16: 145-8 (1978) as cited in Health and Safety Executive Monograph: Trichloroethylene #6 p.3 (1982)].

11. When (14)C-trichloroethylene was administered by im injection at a dose of 50 mg/kg, the radioactivity excreted in the urine and feces ranged from 40-60% of the dose in chimpanzees, 11-28% in baboons, and 7-40% in rhesus monkeys. [Muller WF et al; Chemosphere 11: 215-8 (1982) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.4-23 (1983) EPA-600/8-82-006B].

12. When 18 mg/kg of trichloroethylene in 5 ml of water or corn oil was intragastrically administered to fasting rats (400 g), the peak blood concn (5.6 minutes for aqueous solution) averaged 15 times higher for water than for corn oil solution (14.7 vs <1.0 ug/ml). The peak blood concn was reached faster for water than for oil solution, which exhibited a second delayed peak 80 minutes post-absorption. [Withey JR et al; J Appl Toxicol 3 (5): 249-53 (1983) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.4-2 (1983) EPA-600/8-82-006B].

13. In humans, the blood/air partition coefficient ranges from 9 to 15. Daily body uptake has been estimated to be approximately 6 mg/kg body weight, for an exposure of 4 hr at 378 mg/cu m and /is not influenced/ by the quantity of adipose tissue. [Monster AC et al; Int Arch Occup Environ Health 42: 283-92 (1979) as cited in WHO; Environ Health Criteria: Trichloroethylene p.42 (1985)].

14. Trichloroethylene retention varies according to physical activity. Under laboratory conditions, human volunteers at rest exposed to concentrations of 540 or 1080 mg/cu m for 30 minutes, 50% of the quantity inhaled was retained. The percentage retained decreased from 50% to 25% when activity rose from rest to a 150 watt workload, but, because of increased ventilation, the absolute amount absorbed still increased. [Astrand I, Ovrum P; Scand J Work Environ Health 2: 199-211 (1976) as cited in WHO; Environ Health Criteria: Trichloroethylene p.42 (1985)].

Laboratory and/or Field Analyses:

In the past, many methods have been used to analyze for TCE [861,1010,1011,1013]. EPA methods for NPDES permits are specified in 40 CFR Part 136 [1010]. EPA methods for drinking water are specified in 40 CFR Part 141 [1011].

EPA (RCRA Group) publishes requirements for solid waste methods in 40 CFR Part 261, Appendix III, with details in the following periodically updated publication [1013]:

> Environmental Protection Agency. 1997. Test methods for evaluating solid waste, physical/chemical methods, SW-846, EPA Office of Solid Waste and Emergency Response, EPA, Washington, D.C. Update 3 finalized in 1997. Available from NTIS or GPO. Previous 1995 update 2 was available on CD-ROM [1013].

RCRA (SW-846) methods tend to include provisions for using the specified method or something better. RCRA SW-846 methods typically require instrument calibration before analyses, but some labs don't do it, and many labs actually use some kind of hybrid between RCRA, CERCLA, or various other "standard protocols" (Roy Irwin, Park Service, Personal Communication, 1997, based on conversations with various EPA and lab staff members). The guidance in SW-846 must be used in some states, but is considered "guidance of acceptable but not required methods" in most federal applications. In the past, EPA has also published separate (not SW-846) guidance documents with suggestions on field sampling and data quality assurance related to sampling of sediments [1016] and soils [1017,1018,1019].

EPA (CERCLA) publishes various Contract Laboratory Program (CLP) methods documents periodically, available from EPA and NTIS. CLP methods were designed for use in contaminated areas and often have detection limits that are not low enough for use in relatively clean areas or where low detection levels are needed in comparison with low concentration criteria or benchmarks. CERCLA CLP methods tend to require things done exactly per contract specifications. A few examples of CLP publications (this list is not complete) [861]:

> User's Guide CLP CERCLA User's Guide to the Contract Laboratory Program. USEPA - Office of Emergency and Remedial Response. Dec 1988

> 9240_0-0XFS Multi-Media/Conc Superfund OSWER CERCLA Multi-Media, Multi-Concentration Organic/Inorganic Analytical Service for Superfund, Quick Reference Fact Sheets, 9240.0-08FS (organic) and 9240-0-09FS (inorganic), August 1991. The organic/inorganic analytical service provides a technical and contractual framework for laboratories to apply EPA/Contract Laboratory Program (CLP) analytical methods for the isolation, detection and quantitative measurement of 33 volatile, 64 semi-volatile, 28 pesticide/Aroclor, and 24 inorganic target analytes in water and soil/ sediment environmental samples.

AOC/Contract Laboratory Program (CLP), Routine Analytical Services, Summary on EPA Home Page under Superfund Subdirectory, EPA Office of Remedial and Emergency Response, 1997, Internet.

Detection limits: For optimum risk or hazard assessment work, volatile compound lab methods with very low detection limits should be used. In all cases, they should be lower than comparison benchmarks or standards for various media of concern. Ideally, the detection limit should be at least 10 times higher than the comparison benchmark or criteria [676]. The following dectection limits should be used as default detection limits when potential impacts to living things are being considered.

Water Detection Limits:

GC/HSD methods can achieve 0.03 ppb dectection limits for water [937]. The lower the detection limits, the better for preventing false negatives, and some of the better labs can achieve detection levels of 0.9 ng/L (ppt) in water [601]. In concert with need to compare values with low benchmark concentrations, the regulatory requirements of States such as Wisconsin and the capabilities of better labs, detection limits should be as low as possible. USGS can achieve detection limits of 0.05 ug/L or less for this compound using advanced methods such as USGS 1996 Custom Method 9090. In situations not requiring the lower limits, EPA specifies a water detection limit of 0.12 ug/L for this compound for routine NPDES permit applications using EPA method 601 for purgeable halocarbons (40 CFR, Part 136, Appendix A, Table 1) [1010].

Solids Detection Limits:

GC/ECD (electron capture detector) and GC/HSD (halogen specific detector) methods can achieve 0.03 to 0.23 ppb for tissues, soils, and sediments [937]

.

The investigator should also specify the addition of any associated compounds, such as common breakdown products dichloroethylene, chloromethane, and the especially hazardous compound vinyl chloride. Some tetrachloroethylene breaks down into TCE, so where TCE is present, tetrachloroethylene may also be present (see Fate.Detail section above for more information). Many other associated chemicals which should often be analyzed when TCE is present, but are not on many standard scans include:

Dichloroacetylene, dichloroacetic acid (DCA), trichloroacetic acid (TCA), chloral hydrate, and 2-chloroacetaldehyde [937].

Metabolites of TCE such as [609]:

trichloroacetic acid

Trichloroethanol, free or conjugated

Note: oxidation of trichloroethylene in man can produce the more toxic trichloroethanol and then trichloroacetic acid (see interactions section for more detail).

Urochloralic acid
monochloroacetic acid
chloroform.
chloral
epoxide intermediates

Impurities found in TCE, such as [609]:

Tetrachloroethane
amine
combinations of epoxides such as epichlorohydrin & esters
carbon tetrachloride
chloroform
1,2-dichloroethane
trans 1,2-dichloroethylene,
cis 1,2-dichloroethylene,
pentachloroethane,
1,1,1,2-tetrachloroethane,
1,1,2,2-tetrachloroethane,
1,1,1-trichloroethane,
1,1,2-trichloroethane,
bromodichloroethylene,
benzene.

Trichloroethylene for medicinal purposes may contain some thymol or ammonium carbonate.

Industrial grades of TCE may contain other stabilizers, such as triethanolamines stearate and cresol.

Stabilizers in trichloroethylene formulations include: amyl alcohol, propanol, diethylamine, triethylamine, dipropylamine, diisopropylamine, diethanolamine, morpholine, n-methylmorpholine, aniline, acetone, ethylacetate, borate esters, ethylene oxide, 1,2-propylene oxide, 1,2-epoxybutene, cyclohexene oxide, propylene oxide, butadiene oxide, styrene oxide, pentene oxide, 2,3-epoxy 1-propenol, 3-methoxy-1,2-epoxy propane, stearates, 2-methyl-1,2-epoxypropanol, epoxy cyclopentanol, epichlorohydrin, tetrahydrofuran, tetrahydropyran, 1,4-dioxane, dioxalane, trioxane, alkoxyaldehyde hydrazones, methyl ethyl ketone nitromethanes, nitropropanes, phenol, o-cresol, thymol, p-tert-butylphenol, p-tert-amylphenol, isoeuganol, pyrrole, n-methylpyrrole, n-ethyl pyrrole, (2-pyrryl)-trimethylsilane, glycidyl acetate, isocyanates, and thiazoles (for details, see

Forms/Preparations/Formulations section above).

Holding Times:

Water Samples: According to EPA protocols for NPDES permits, the maxiumum holding time for all purgeable halocarbons is 14 days; samples should be kept iced or refrigerated, with no headspace or bubbles in the container (40 CFR, Part 136,3, 1994) [1010].

Samples of Solids: EPA RCRA methods for volatiles in solids in SW-846 call for holding times of 14 days [1013].

Field Protocols:

Standard field collection method protocols are published or distributed internally by the Fish and Wildlife Service, the USGS, DOE, NOAA, and EPA. These recommendations change over time, with the newest recommendations sometimes being quite different than the old, thereby producing different results. The Fish and Wildlife Service methods are similar in many ways to NOAA field protocols [676]. Many recommended EPA field methods for organics are not very detailed, although the 3rd update of SW-846 for RCRA solid waste methods has more field method details for method 5035 [1013].

The various EPA methods for organics are different from each other, with the selection of the appropriate method depending upon the specific application (RCRA vs. CERCLA vs. NPDES permits, vs. Drinking Water, etc.) [861,1010,1013]. The EPA-recommended field methods are scattered through various EPA and ASTM publications.

EPA requires proper cleaning for both volatile and semi-volatile organics [1010,1013].

ASTM publishes standard method guidance for numerous very specific applications, like sampling from pipes (D 3370-95a) and sampling for VOCs in soils (ASTM method D 4547].

EPA methods typically include recommendations that grab samples rather than composites be utilized for organics in NPDES [1010] and solid waste [1013] applications. In other publications, EPA recommends caution in the use of composite soil samples whether organic or inorganic, citing statistical complications and stating that the compositing of samples cannot, in general, be justified unless for a stated specific purpose and unless a justification is provided [1017]. Mixing composite samples of volatile samples (and even samples of the lighter semi-volatiles such as naphthalene) is not advisable since some of the compounds can thereby be lost through volatization to the air during the mixing process (Roy Irwin, National Park Service, Personal Communication, 1997)

Containers: Both EPA and APHA (Standards Methods Book) recommend glass containers for the collection of organic compounds [141,1010,1013]. EPA also recommends teflon lined caps for samples of volatiles in solids [1010,1013]. For water samples of VOCs and purgeable halocarbons such as the common organic solvents, EPA specifies the use of teflon lined caps and teflon lined cap septums in glass vial containers [1010]. No headspace is allowed [1010]. Actually, vials are not the best choice for avoiding false negatives in soil samples through volatilization losses, since the use of brass liners for collection resulted in 19 fold higher VOCs than when 40 mL vials were used [798] (see Wisconsin protocol discussion below). The third update of SW-846 authorizes the storage of volatiles in EnCoreTM (or equivalent, no government endorsement implied) samplers as long the sample is analyzed within 48 hours after collection [1013], as do several states (Donalea Dinsmore, State of Wisconsin DNR, personal communication, 1997).

Guidance from other federal agencies (USGS, FWS, NOAA) also recommends glass containers for organics, and discourages the use of plastic containers for a variety of reasons (Roy Irwin, National Park Service, Personal Communication, 1997, based on a glance through recent internal guidance of several agencies). Some federal agency quality control procedures call for voiding or red-flagging the results of organic analyses if the lab receives the sample in plastic containers (Roy Irwin, National Park Service, Personal Communication, 1997). The APHA pointed out some the potential hazards of the use of certain plastic containers for storing organic samples [141]:

A) Potential contamination of the sample via leaching of compounds from the plastic, and/or

B) The plastic container walls can sometimes be attacked by certain organics and fail, and/or

C) The possibility that some of organic compound will dissolve into the walls of the plastic container, reducing the concentration of the compound in the container [141].

Typical "standard method" protocols recommend proper cleaning of glass containers before use. Some collectors simply use pre-cleaned jars from I-Chem or Eagle Pitcher (no government endorsement implied) or equivalent suppliers. EPA [1010], USGS, and most other federal agencies recommend cleaning procedures for the glass containers, usually involving detergent rinsing, baking, and sometimes HCL rinses (Roy Irwin, National Park Service, Personal Communication, 1997)..

Regardless of what lab methods are used, the investigator must take special precautions to prevent the escape of volatiles during sample shipment, storage, extraction, and cleanup [798]. This is especially true for soil and sediment sampling. The results of analyses of volatiles can be dramatically effected by small details such as how the samples are collected, stored, held, and analyzed in the lab, since volatile compounds can readily volatilize from samples in both field and lab procedures.

The realization that better methods were needed began when the lab results of EPA methods 8020 and 8240 were negative even when contamination by volatiles was obvious in the field, in other words, when investigators began seeing clearly false negative results [798]. In one study, the use of brass liners for collection of soil samples resulted in 19 fold higher VOCs than when 40 mL vials were used [798].

National guidance for minimizing loss of volatiles in field sampling is found in EPA RCRA method 5035 as described in update 3 of SW-846 [1013,1018]. Several states (WI,MN,NJ, and MI) have developed their own detailed guidance, often including the use of methanol as a preservative.

After researching various papers which documented volatile losses of 9 to 99% during sampling and then finding 100% losses in samples held over 14 days in their own facilities, the Wisconsin DNR requires the following for soil sampling of volatiles [913]:

1) Concentrated (1:1 by weight of preservative vs soil) methanol preservation be used for all samples [913], and

2) samples stored in brass tubes must be preserved in methanol within 2 hours and samples stored in EnCoreTM samplers must be preserved in 48 hours [913].

3) Detection limits should be no higher than 25 ug/Kg (ppb) dry weight for VOCs or petroleum volatiles in soil samples [913].

> Note: The use of methanol for soil sample preservation can make lower detection limits difficult, but the tradeoff can be worth it since otherwise high percentages of volatiles can be lost in very short periods of time, for example in 2 hours for benzene. In other words, low detection limits do not help much if you are losing all the volatiles from the soil sample before analysis. A possible alternative to using methanol for soil samples of volatiles would be to use the EnCoreTM sampler and to analyze as soon as possible (no later than 48 hours) after collection using the methods that give lower detection limits (Donalea Dinsmore, State of Wisconsin DNR, personal communication, 1997).

The USGS NAWQA program also recognized the problem of potential losses of volatile compounds, and recommends the use of strong (1:1) HCL as preservative material. Some SW-846 methods call for the use of sulfuric acid [1013].

Variation in concentrations of organic contaminants may sometimes be due to the typically great differences in how individual investigators treat samples in the field and in the lab rather than true differences in environmental concentrations. This is particularly true for volatiles, which are so easily lost to the air at various steps along the way. Contaminants data from different labs, different states, and different agencies, collected by different people, are often not very comparable (see disclaimer section at the top of this entry for more details).

As of 1997, the problem of lack of data comparability (not only for water methods but also for soil, sediment, and tissue methods) between different "standard methods" recommended by different agencies seemed to be getting worse, if anything, rather than better. The trend in quality assurance seemed to be for various agencies, including the EPA and others, to insist on quality assurance plans for each project. In addition to quality control steps (blanks, duplicates, spikes, etc.), these quality assurance plans call for a step of insuring data comparability [1015,1017]. However, the data comparability step is often not given sufficient consideration. The tendency of agency guidance (such as EPA SW-846 methods and some other new EPA methods for bio-concentratable substances) to allow more and more flexibility to select options at various points along the way, makes it harder in insure data comparability or method validity. Even volunteer monitoring programs are now strongly encouraged to develop and use quality assurance project plans [1015].

However, it should be kept in mind that quality control field and lab blanks and duplicates will not help in the data quality assurance goal as well as intended if one is using a method prone to false negatives. Methods may be prone to false negatives due to the use of detection limits that are too high, the loss of contaminants through inappropriate handling, or the use of inappropriate lab or field methods. The loss of volatliles through inappropriate sampling and storage methods is particularly common related to solvent VOCs such as this one.

The basics of quality assurance plans for chemical analyses should include the following quality control steps:

> At minimum, before using contaminants data from diverse sources, one should determine that field collection methods, detection limits, and lab quality control techniques were acceptable and comparable. The goal is that the analysis in the concentration range of the comparison benchmark concentration should be very precise and accurate. Typical lab quality control techniques should have included the following considerations (John Moore, Fish and Wildlife Service, Personal Communication, 1997):
>
> Procedural Blanks should be analyzed to assure that no contaminants are added during the processing of the samples. The standards for adequacy depend on the method and the media being measured.
>
>> Different federal agencies publish different acceptable limits. For one program, NOAA stated that at least 8% of samples should be blanks, reference or control materials

[676].

The basic idea is that neither samples nor blanks should be contaminated. Because the only way to measure the performance of the modified procedures is through the collection and analysis of uncontaminated blank samples in accordance with this guidance and the referenced methods, it is highly recommended that any modifications be thoroughly evaluated and demonstrated to be effective before field samples are collected [1003].

Duplicate samples are analyzed to provide a measure of precision of the methods. The standards for adequacy depend on the method and the media being measured.

Different federal agencies publish different acceptable limits. There appears to be an inverse relationship between precision and sensitivity [676].

Some EPA methods state that a field duplicate must be collected at each sampling site, or one field duplicate per every ten samples, whichever is more frequent [1003]. Some protocols call for the preparation of one Ongoing precision and recovery (OPR) standard for every ten or fewer field samples. Great care should be taken in preparing ongoing precision and recovery standards [1003].

Spiked samples are analyzed to provide a measure of the accuracy of the analysis methods. The standards for adequacy depend on the method and the media being measured.

Different federal agencies publish different acceptable limits.

Description of Custom Method 9090: Basic Description of the Method (Brooke Connor, USGS Water Quality Lab, Denver, Personal Communication, 1996):

Tue, 14 May 1996 From: "John S Zogorski, Supervisory Hydrologist, Rapid City, SD" Custom Method 9090: Basic Description of the Method, Identification and Quantification Strategy, and Data Transfer.

General Description of the Method: Custom method 9090 uses capillary column gas chromatography / mass spectrometry (GC/MS) to identify and quantitate 87 analytes, and to tentatively identify unknowns. The method is intended to identify and measure low concentrations of VOCs that may occur in the environmental settings sampled in the NAWQA program, and which may be associated with either point and non-point sources, especially in urban areas. Fifty-five of the analytes included on 9090 are referred to as NAWQA VOC target analytes and were selected because of their known human health concern

> (A or B carcinogens), aquatic toxicity, frequency of occurrence, and/or emerging chemicals with a potential for wide-scale use and significance. Custom method 9090 builds on the same VOC analytical technology, GC/MS, that has been used at the NWQL and elsewhere for many years, and which is considered the conventional approach for high-quality analysis of VOCs in water.... Persons unfamiliar with the GC/MS method for VOCs may wish to refer to 2 recent reports: Rose, D.L., and M.P. Schroeder, 1995, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory -- Determination of volatile organic compounds in water by purge and trap capillary gas chromatography/mass spectrometry: U.S. Geological Survey Open-File Report 94-708, 26 p. Raese, J.W., D.L Rose, and M.W. Sandstrom, 1995, U.S. Geological Survey Laboratory Method for Methyl tert-Butyl Ether and Other Fuel Oxygenates: U.S. Geological Survey Fact Sheet 219-95, 4 p.

For drinking water, in the past, EPA has recommended the following less rigorous methods for analyses of certain volatiles: Purge and trap capillary gas chromatography (EPA 502.2); gas chromatographic/mass spectrometry (EPA 524.2); purge and trap gas chromatography (EPA 503.1); gas chromatography/mass spectrometry (EPA 524.1); PQL= 0.005 mg/L [893]. These detection limits are no longer low enough. Previous monitoring Requirements for drinking water for this compound [893]:

> All systems to be monitored for four consecutive quarters; repeat monitoring dependent upon detection and vulnerability status and system size.
>
> Gas chromatography (EPA 502.1, 502.2, 503.1): gas chromatographic/mass spectrometry (EPA 524.1, 524.2) [893].

Description of EPA standard methods 8240 and 8260 (8260 is replacing 8240) from EPA EMMI Database on Lab methods [861]:

> EPA Method 8240 for Volatile Organics [861]:
>
> > OSW 8240A S Volatile Organics - Soil, GCMS 73 SW-846 GCMS ug/kg EQL Method 8240A "Volatile Organics by Gas Chromatography/Mass Spectrometry (GC/MS): Packed Column Technique" The volatile compounds are introduced into the gas chromatograph by the purge and trap method or by direct injection (in limited applications) [861]. The components are separated via the gas chromatograph and detected using a mass spectrometer, which is used to provide both qualitative and quantitative information [861]. The chromatographic conditions, as well as typical mass spectrometer operating parameters, are given [861]. If the above sample introduction techniques

are not applicable, a portion of the sample is dispersed in methanol to dissolve the volatile organic constituents [861]. A portion of the methanolic solution is combined with organic-free reagent water in a specially designed purging chamber [861]. It is then analyzed by purge and trap GC/MS following the normal water method [861]. The purge and trap process - An inert gas is bubbled through the solution at ambient temperature, and the volatile components are efficiently transferred from the aqueous phase to the vapor phase [861]. The vapor is swept through a sorbent column where the volatile components are trapped [861]. After purging is complete, the sorbent column is heated and backflushed with inert gas to desorb the components, which are detected with a mass spectrometer [861].

Note: Method 8260 is replacing 8240 in the third update of SW-846 [1013].

OSW 8240A W Volatile Organics - Water, GCMS 73 SW-846 GCMS ug/L EQL Method 8240A "Volatile Organics by Gas Chromatography/Mass Spectrometry (GC/MS): Packed Column Technique" The volatile compounds are introduced into the gas chromatograph by the purge and trap method or by direct injection (in limited applications) [861]. The components are separated via the gas chromatograph and detected using a mass spectrometer, which is used to provide both qualitative and quantitative information [861]. The chromatographic conditions, as well as typical mass spectrometer operating parameters, are given [861]. If the above sample introduction techniques are not applicable, a portion of the sample is dispersed in methanol to dissolve the volatile organic constituents [861]. A portion of the methanolic solution is combined with organic-free reagent water in a specially designed purging chamber [861]. It is then analyzed by purge and trap GC/MS following the normal water method [861]. The purge and trap process - An inert gas is bubbled through the solution at ambient temperature, and the volatile components are efficiently transferred from the aqueous phase to the vapor phase [861]. The vapor is swept through a sorbent column where the volatile components are trapped [861]. After purging is complete, the sorbent column is heated and backflushed with inert gas to desorb the components, which are detected with a mass spectrometer [861].

EPA Method 8260 (replacing 8240 as a GC/MS method for

Volatile Organics):

Note: Method 8260 is replacing 8240 in the third update of SW-846 [1013].

EPA description [861]:

OSW 8260 Volatile Organics - CGCMS 58 SW-846 CGCMS ug/L MDL Method 8260 "Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique" The volatile compounds are introduced into the gas chromatograph by the purge and trap method or by direct injection (in limited applications) [861]. Purged sample components are trapped in a tube containing suitable sorbent materials [861]. When purging is complete, the sorbent tube is heated and backflushed with helium to desorb trapped sample components [861]. The analytes are desorbed directly to a large bore capillary or cryofocussed on a capillary precolumn before being flash evaporated to a narrow bore capillary for analysis [861]. The column is temperature programmed to separate the analytes which are then detected with a mass spectrometer interfaced to the gas chromatograph [861]. Wide capillary columns require a jet separator, whereas narrow bore capillary columns can be directly interfaced to the ion source [861]. If the above sample introduction techniques are not applicable, a portion of the sample is dispersed in solvent to dissolve the volatile organic constituents [861]. A portion of the solution is combined with organic- free reagent water in the purge chamber [861]. It is then analyzed by purge and trap GC/MS following the normal water method [861]. Qualitative identifications are confirmed by analyzing standards under the same conditions used for samples and comparing resultant mass spectra and GC retention times [861]. Each identified component is quantified by relating the MS response for an appropriate selected ion produced by that compound to the MS response for another ion produced by an internal standard [861]. EPA 8260 is replacing 8240.

Other Misc. (mostly less rigorous) lab methods which have been used in the past in media such as drinking water for volatiles [893] (lab method description from EPA [861]):

EMSLC 502.2 ELCD VOA's - P&T/CGCELCD/CGCPID 44 DRINKING_WATER CGCELD ug/L MDL "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series" This method is used for the identification and measurement of purgeable volatile organic compounds in finished drinking water, raw source water, or drinking water in any treatment stage [861]. The method is applicable to a wide range of organic compounds, including the four trihalomethane disinfection by-products, that have sufficiently high volatility and low water solubility to be efficiently removed from water samples with purge and trap procedures [861]. An inert gas is bubbled through a 5 mL water sample [861]. The volatile compounds with low water solubility are purged from the sample and trapped in a tube containing suitable sorbent materials [861]. When purging is complete, the tube is heated and backflushed with helium to desorb trapped sample components onto a capillary gas chromatography (GC) column [861]. The column is temperature programmed to separate the analytes which are then detected with photoionization detector (PID) and halogen specific detectors in series [861]. Analytes are identified by comparing retention times with authentic standards and by comparing relative responses from the two detectors [861]. A GC/MS may be used for further confirmation [861].

EMSLC 502.2 PID VOA's - P&T/CGCELCD/CGCPID 33 DRINKING_WATER CGCPID ug/L MDL "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series" This method is used for the identification and measurement of purgeable volatile organic compounds in finished drinking water, raw source water, or drinking water in any treatment stage [861]. The method is applicable to a wide range of organic compounds, including the four trihalomethane disinfection by-products, that have sufficiently high volatility and low water solubility to be efficiently removed from water samples with purge and trap procedures [861]. An inert gas is bubbled through a 5 mL water sample [861]. The volatile compounds with low water solubility are purged from the sample and trapped in a tube containing suitable sorbent materials [861]. When purging is complete, the tube is heated and backflushed with helium to desorb trapped sample components onto a capillary gas chromatography (GC) column [861]. The column is temperature programmed to separate the analytes which are then detected with photoionization detector (PID) and halogen specific detectors in series [861]. Analytes are identified by comparing retention times with authentic standards and by comparing relative responses from the two detectors [861]. A GC/MS may be used for further confirmation [861].

EMSLC 503.1 Volatile Aromatics in Water 28 DRINKING_WATER GCPID ug/L MDL "Volatile Aromatic and Unsaturated Organic Compounds in Water by Purge and Trap Gas Chromatography" This method is applicable for the determination of various volatile aromatic and unsaturated compounds in finished drinking water, raw source water, or drinking water in any treatment stage [861]. Highly volatile organic compounds with low water solubility are extracted (purged) from a 5-ml sample by bubbling an inert gas through the aqueous sample [861]. Purged sample components are trapped in a tube containing a suitable sorbent material [861]. When purging is complete, the sorbent tube is heated and backflushed with an inert gas to desorb trapped sample components onto a gas chromatography (GC) column [861]. The gas chromatograph is temperature programmed to separate the method analytes which are then detected with a photoionization detector [861]. A second chromatographic column is described that can be used to help confirm GC identifications or resolve coeluting compounds [861]. Confirmation may be performed by gas chromatography/mass spectrometry (GC/MS) [861].

APHA 6230 D Volatile Halocarbons - CGCELCD STD_METHODS GCELCD "6230 Volatile Halocarbons" GCPID 6230 D [861]. Purge and Trap Capillary-Column Gas Chromatographic Method: This method is similar to Method 6230 C., except it uses a wide-bore capillary column, and requires a high-temperature photoionization detector in series with either an electrolytic conductivity or microcoulometric detector [861]. This method is equivalent to EPA method 502.2; see EMSLC\502.2 [861]. Detection limit data are not presented in this method, but the method is identical to 502.2; therefore, see EMSLC\502.2 for detection limit data [861]. Method 6230 B., 17th edition, corresponds to Method 514, 16th edition [861]. The other methods listed do not have a cross-reference in the 16th edition [861].

EMSLC 524.1 Purgeable Organics - GCMS 48 DRINKING_WATER GCMS ug/L MDL "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry" This is a general purpose method for the identification and simultaneous measurement of purgeable volatile organic compounds in finished drinking water, raw source water, or drinking water in any treatment stage [861]. Volatile organic compounds and surrogates with low water solubility are extracted (purged) from the sample matrix by bubbling an inert gas through the aqueous sample [861]. Purged sample components are trapped in a tube containing suitable sorbent materials [861]. When purging is complete, the trap is backflushed with helium to desorb the trapped sample components into a packed gas chromatography (GC) column interfaced to a mass spectrometer (MS) [861]. The column is temperature programmed to separate the method analytes which are then detected with the MS [861]. Compounds eluting from the GC column are identified by comparing their measured mass spectra and retention times to reference spectra and retention times in a data base [861]. Reference spectra and retention times for analytes are obtained by the measurement of calibration standards under the same conditions used for samples [861]. The concentration of each identified component is measured by relating the MS response of the quantitation ion produced by that compound to the MS response of the quantitation ion produced by a compound that is used as an internal standard [861]. Surrogate analytes, whose concentrations are known in every sample, are measured with the same internal standard calibration procedure [861].

EMSLC 524.2 Purgeable Organics - CGCMS 60 DRINKING_WATER CGCMS ug/L MDL "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry" This is a general purpose method for the identification and simultaneous measurement of purgeable volatile organic compounds in finished drinking water, raw source water, or drinking water in any treatment stage [861]. Volatile organic compounds and surrogates with low water solubility are extracted (purged) from the sample matrix by bubbling an inert gas through the aqueous sample [861]. Purged sample components are trapped in a tube containing suitable sorbent materials [861]. When purging is complete, the sorbent tube is heated and backflushed with helium to desorb the trapped sample components into a capillary gas chromatography (GC) column interfaced to a mass spectrometer (MS) [861]. The column is temperature programmed to separate the method analytes which are then detected with the MS [861]. Compounds eluting from the GC column are identified by comparing their measured mass spectra and retention times to reference spectra and retention times in a data base [861]. Reference spectra and retention times for analytes are obtained by the measurement of calibration standards under the same conditions used for samples [861]. The concentration of each identified component is measured by relating the MS response of the quantitation ion produced by that compound to the MS response of the quantitation ion produced by a compound that is used as an internal standard [861]. Surrogate analytes, whose concentrations are known in every sample, are measured with the same internal standard calibration procedure [861].

ATSDR has summarized additional methods for biological and other media [937].