ENVIRONMENTAL CONTAMINANTS ENCYCLOPEDIA
CARBON TETRACHLORIDE ENTRY

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Like a library or most 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 with out 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 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).

Carbon Tetrachloride (Carbon Tet., Tetrachloromethane, CAS number 56-23-5)

Brief Introduction:

Br.Class: General Introduction and Classification Information:

Carbon tetrachloride is a volatile organic compound (VOC) [868,903]. A halogenated methane [656]. It also is considered a purgeable halocarbon, one of the many compounds sometimes analzed with EPA method 601 (40 CFR, Part 136, Appendix A, page 400, 1994).

Carbon tetrachloride is often of concern at hazardous wastes sites or anywhere solvents have been used or disposed. Carbon tetrachloride is a clear, colorless, nonflammable, heavy liquid with a pleasant, characteristic odor [270]. It evaporates easily and most of the carbon tetrachloride that escapes to the environment is found as a gas in the atmosphere [930].

Carbon tetrachloride does not occur naturally but has been produced in large quantities to make refrigeration fluid and propellants for aerosol cans. Since refrigerants and aerosol propellants have been found to affect the earth's ozone layer, the production of these chemicals is being phased out. Consequently, the manufacture and use of carbon tetrachloride will probably decline in the future [930].

Since the U.S Food and Drug Administration banned the sale of carbon tetrachloride in any product used in the home, its production initially declined at approximately 8% a year from 1974 to 1981 [930].

In the past, carbon tetrachloride was widely used as a cleaning fluid, both in industry and dry cleaning establishments, where it served as a degreasing agent, and in the household, where it was used to remove spots from clothing, furniture, and carpeting. Carbon tetrachloride was also used in fire extinguishers and as a fumigant to kill insects in grain. These uses were discontinued in the mid-1960s. Until recently, carbon tetrachloride was used as a pesticide, but this was stopped in 1986 [930].

Carbon tetrachloride is a carcinogenic priority pollutant [446]. It is a solvent among 31 substances classified by the Chief of the Worker Health and Safety Unit of the California Department of Food and Agriculture as having "high carcinogenic or oncogenic potential" (Dr. Keith Maddy, personal communication). It is on EPA's restricted use list of pesticides and is a class B2 carcinogen, sufficient evidence to be classed as an animal carcinogen.

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, 7/1/90) [940].

Toxic pollutant designated pursuant to section 307(a)(1) of the Clean Water Act and is subject to effluent limitations (40 CFR 401.15, 7/1/90) [940].

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, 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 high concentrations immediately after a spill (before the compound has volatilized into the atmosphere) or be the indirect result of contamination of groundwater. For example, if highly polluted groundwater water comes into surface waters from springs or seeps, local effects may occur in the mixing zone where the groundwater enters surface water.

Poisoning in animals is commonly acute, following administration of the compound as a antihelmintic. Symptoms include a loss of appetite, dullness, staggering gait, evidence of gastrointestinal disturbances with passage of blood stained feces, constipation followed by diarrhea, collapse, and death (Clarke, E.G., and M. L. Clarke. Veterinary Toxicology. Baltimore, Maryland: The Williams and Wilkins Company, 1975. 129) [940].

Concurrent treatment of mammals with carbon tetrachloride & other substances, including DDT Increases susceptibility to carbon tetrachloride toxicity: various other interactions other substances can also be important (see Interactions section below for details).

Potential Hazards to Humans:

Carbon tetrachloride is poisonous and accumulates within the body; excessive intake through ingestion, inhalation, or skin absorption may result in liver damage [270].

There are 3 primary routes of human exposure - water and other fluids, inhalation, and ingestion of foodstuffs(1). Significant amounts (30 million pounds) each year are used for degreasing products, fire extinguishers, grain fumigants, etc (Chemical Marketing Reporter February 21 Chemical Profile, 1983) [940].

Exposure at polluted sites would occur by breathing carbon tetrachloride present in the air, by drinking water contaminated with carbon tetrachloride, or by getting soil contaminated with carbon tetrachloride on the skin [930]. Young children may also be exposed if they eat soil that contains carbon tetrachloride [930].

Symptomatology: 1. Prompt nausea, vomiting, and abdominal pain ... After ingestion, hematemesis and diarrhea. 2. Headache, dizziness, confusion, drowsiness, and occasionally convulsions. 3. Visual disturbances, sometimes consisting of a concentric restriction of the color fields without central scotomata (toxic amblyopia). 4. Rapid progression of central nervous depression with deepening coma and death from respiratory arrest or circulatory collapse. 5. Occasionally sudden death due to ventricular fibrillation. ... 6. In massive exposures the above symptoms merge with those outlined below, but central nervous depression may subside without sequelae ... or an essentially asymptomatic interval of a few days may precede hepatorenal decompensation. 7. Kidney and/or liver injury, symptomatic or subclinical ... 8. Oliguria, albuminuria, anuria, gradual weight gain, edema. Death may occur within 1 wk in the absence of effective supportive treatment. 9. Anorexia, jaundice, and right upper quadrant pain due to an enlarged and tender liver. 10. Carpopedal spasm that was relieved by calcium gluconate appears to be a very rare reaction (Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-105) [940].

Carbon tetrachloride in the environment may pose a long-term danger because of its possible carcinogenic potential. In urban and industrial areas where higher concentrations of carbon tetrachloride in the air occur, other toxic effects such as liver and renal damage may result (USEPA; Health Assessment Document: Carbon Tetrachloride p.2-7, 1984, EPA-600/8-82-001F) [940].

Target organs: CNS, eyes, lungs, liver, kidneys, skin (NIOSH Pocket Guide to Chemical Hazards, NIOSH Publication No. 90-117. Washington, DC: U.S. Government Printing Office, June 1990, 60) [940].

Carbon tetrachloride is a CNS depressant (USEPA, Office of Drinking Water; Criteria Document (Final Draft of Document on Carbon Tetrachloride, 1982. p.II-2 Contract No 2-813-03-644-09) [940].

A comprehensive toxicological profile for carbon tetrachloride, especially as it relates to human health, is available from ATSDR [930]. Due to lack of time, not all important highlights from this ATSDR document have not yet been completely incorporated into this entry.

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 [940], EPA IRIS database [893], and the ATSDR Human Toxicology Profile [930].

EPA has a free several-page health advisory on this compound, available through the Office of Drinking Water, EPA, Washington, D.C. or through NTIS.

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

EPA 1996 IRIS database information [893]:

CLASSIFICATION: B2; probable human carcinogen.

BASIS FOR CLASSIFICATION: Carcinogenicity in rats, mice, and hamsters.

HUMAN CARCINOGENICITY DATA: Inadequate.

ANIMAL CARCINOGENICITY DATA: Sufficient.

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

It is not clear whether developmental toxicity could be an area of concern in humans after oral exposure [930].

In rats that inhaled carbon tetrachloride vapors for three generations, there was a decrease in fertility in animals exposed to concentrations 200 ppm or higher. Since both sexes were exposed, it was not possible to determine if this was due to effects in males, females, or both. Moderate to marked degeneration of testicular germinal epithelium has been seen in rats exposed repeatedly to 200 ppm or higher for 192 days [930]. No effect on reproduction was detected in rats exposed to carbon tetrachloride by the oral route for 5-6 weeks. These data are not extensive enough to draw firm conclusions, but it does not appear likely that reproductive effects are of major concern at typical human exposure levels to carbon tetrachloride [930].

Suggestive evidence of genotoxicity was noted in one study in yeast, but only at concentrations of carbon tetrachloride (34mM) considerably above the solubility of carbon tetrachloride in water (5mM) [930].

Fetuses of rats exposed for 7 hr/day on days 6-15 of gestation to concn of 1890 & 6300 mg/cu m (300 and 1000 ppm) carbon tetrachloride in air showed retarded development (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 385, 1979) [940].

Population at special risk: the unborn (Schwetz BA et al; Toxicol Appl Pharmacol 28: 452, 1974, as cited in USEPA/ECAO; Atlas Document for: Carbon Tetrachloride p.32, 1981) [940].

Som IP doses... led to impairments in spermatogenesis which was confirmed by histological examination... Some treated rats showed slight testicular damage, a decrease in the lumen size and other effects (Kalla NR, Bansal MP; Act Anat 91: 380-5, 1975, as cited in USEPA, Office of Drinking Water; Criteria Document: Carbon Tetrachloride p.VI-18, 1982, Contract No. 2-800-00-200-19] [940].

Carbon tetrachloride is not teratogenic to rats exposed orally, SC, or via inhalation (National Research Council. Drinking Water & Health. Volume 5. Washington, D.C.: National Academy Press, 1983. 18) [940].

Carbon tetrachloride was not mutagenic in bacteria. It was mutagenic in yeast at almost lethal doses. (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. 54 74, 1982) [940].

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

Because liquid carbon tetrachloride evaporates easily, most of the compound released to the environment during its production and use reaches the air where it is found mainly as a gas. It can remain in air for several years before it is broken down to other chemicals. Small amounts of carbon tetrachloride are found in surface water, where it does not photodegrade or oxidize in measurable amounts. Because it evaporates easily, much of it will travel from surface water to the air within a few days or weeks, but it may be trapped in groundwater. Carbon tetrachloride is not expected to stick to soil particles. Much of it will evaporate to the air and some of it will go to the groundwater where it can remain for months before it is broken down to other chemicals. It is not expected to build up in fish. It is not known if it builds up in plants [930].

Large quantities of carbon tetrachloride are produced each year; most of it is used for chemical synthesis of fluorocarbons and this has been declining. Some past solvent uses have been resulted in releases. In the troposphere, carbon tetrachloride is extremely stable (residence time of 30-50 years). The primary loss process is by escape to the stratosphere where it photolyzes. As a result of its emission into the atmosphere and slow degradation, the amount of carbon tetrachloride in the atmosphere has been increasing. Some carbon tetrachloride released to the atmosphere is expected to partition into the ocean. In water systems, evaporation appears to be the most important removal process, although biodegradation may occur under aerobic and anaerobic conditions (limited data). Releases or spills on soil should result in rapid evaporation due to high vapor pressure and leaching in soil resulting in groundwater contamination due to its low adsorption to soil. Bioconcentration is not significant [940].

Because carbon tetrachloride is ubiquitous in air, it is likely that trace levels of carbon tetrachloride are present in surface soils around the globe [930].

Synonyms/Substance Identification:

CARBON CHLORIDE [940]
CARBON CHLORIDE (CCL4) [940]
CARBON TET [940]

CZTEROCHLOREK WEGLA (POLISH) [940]
ENT 4,705 [940]
METHANE TETRACHLORIDE [940]
METHANE, TETRACHLORO- [940]
PERCHLOROMETHANE [940]
R 10 [940]
TETRACHLOORKOOLSTOF (DUTCH) [940]
TETRACHLOORMETAAN [940]
TETRACHLORKOHLENSTOFF, TETRA (GERMAN) [940]
TETRACHLORMETHAN (GERMAN) [940]
TETRACHLOROCARBON [940]
TETRACHLOROMETHANE [940]
TETRACHLORURE DE CARBONE (FRENCH) [940]
TETRACLOROMETANO (ITALIAN) [940]
TETRACLORURO DI CARBONIO (ITALIAN) [940]
Benzinoform [940]
UNIVERM [940]
VERMOESTRICID [940]
NECATORINA [940]
NECATORINE [940]
FASCIOLIN [940]
FLUKOIDS [940]
R 10 (Refrigerant) [940]
TETRAFINOL [940]
TETRAFORM [940]
TETRASOL [940]
CARBONA [940]
Freon 10 [940]
Halon 104 [940]

Molecular Formula:
C-Cl4 [940]

Associated Chemicals or Topics (Includes Transformation Products):

Site Assessment-Related Information Provided by Shineldecker (Potential Site-Specific Contaminants that May be Associated with a Property Based on Current or Historical Use of the Property) [490]:

Raw Materials, Intermediate Products, Final Products, and Waste Products Generated During Manufacture and Use:

- Carbon disulfide
- Sulfur chloride

Metabolites [940]:

Carbon tetrachloride is metabolized primarily by liver mixed function oxidase system to a trichloromethyl radical. This radical can undergo various reactions: 1) dimerization to hexachloroethane; 2) reduction to chloroform; and 3) irreversible binding to hepatic macromolecules. Metabolism of the cytochrome-bound trichloromethyl moiety via carbonyl chloride (phosgene) to carbon monoxide and carbon dioxide also occurs. [USEPA, Office of Drinking Water; Criteria Document (Draft): Carbon Tetrachloride p.14 (1980) Contract No. 2-800-00-200-19].

Liver tissue reduces carbon tetrachloride to chloroform, and it was suggested that homolytic cleavage of carbon-chlorine bond yields free radicals which can then alkylate the sulfhydryl groups of enzymes. [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. V1 57 (1972)].

In rat (14)c-carbon tetrachloride is mostly eliminated unchanged in expired air (85% ... In 18 hr) ... Metabolized to small extent into co2 (1%) by enzymes of liver & kidney. [Parke, D. V. The Biochemistry of Foreign Compounds. Oxford: Pergamon Press, 1968. 211].

Eight dogs were exposed to 8000 mg/hr carbon tetrachloride for 3 hours by tracheal cannula. Exhaled air was collected and chlorinated hydrocarbons identified by both gas chromatography and the Fujiwara reaction. Chloroform was estimated via (GC) tube 0.1-0.5 mg/2 hours. Tissue homogenates were also shown to metabolize carbon tetrachloride to chloroform. [Butler TC; J Pharm Exp Ther 134: 311-19 (1961) as cited in USEPA, Office of Drinking Water; Criteria Document (Final Draft): Carbon Tetrachloride p.IV-6 (1982) Contract No. 2-813-03-644-09].

(14)C carbon tetrachloride has been observed to bind irreversibly to rabbit microsomal proteins at a rate approximately 20 nM/mg of protein/hr. Binding of carbon tetrachloride (or its metabolites) to hepatic macromolecules was enhanced in the absence of oxygen. [Uehleke H, Warner TH; Arch Toxicol 34: 289-308 (1975) as cited in USEPA, Office of Drinking Water; Criteria Document (Final Draft): Carbon Tetrachloride p.VIII-2 (1982) Contract No. 2-813-03-644-09].

Five Wistar rats were administered 160 to 800 mg carbon tetrachloride in liquid paraffin by gavage following a 24 hr fast. The animals were sacrificed 15 min to 8 hours after treatment. Carbon tetrachloride concn in rat liver was approximately 0.9 mg/kg of tissue after 15 minutes and at maximal concn of 1.7 mg/kg after 120 minutes. Chloroform /concentration/ was maximal at 0.037 mg/kg after 15 minutes; after 4 hours it had declined to 0.007 mg/kg. Hexachloroethane was present after 4 hours at concentrations of 0.005 mg/kg. [Bini A et al; Pharmacol

Res Comm 7: 143-9 (1975)].

To identify intermediates of carbon tetrachloride metabolism, fortified rat liver homogenates were incubated with (14)C in the presence and absence of pools of unlabeled suspected intermediates. In the presence of NADH or NADPH, incorporation of radioactivity was rapid and substantial in CO2, lipid, protein, and the acid-soluble fraction. It was not influenced by the presence of large pools of unlabeled chloroform or formate, excluding these substances as obligatory intermediates. When incubated with L-cysteine, radioactivity incorporation in the acid-soluble fraction was almost doubled; about 1/3 of the radioactivity of this fraction was identified as 2-oxothiazolidine-4-carboxylic acid. [Shah H et al; Cancer Res 39 (10): 3942-7 (1979)].

Biochemical evidence of hepatic injury often incl greatly elevated activities of transaminases and a variety of other hepatic enzymes in plasma. Alkaline phosphatase activity is, however, only slightly elevated. The chief histological abnormalities incl hepatic steatosis and hepatic centrilobular necrosis. ... [Gilman, A.G., T.W. Rall, A.S. Nies and P. Taylor (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 8th ed. New York, NY. Pergamon Press, 1990. 1622].

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

W.Low (Water Concentrations Considered Low):

Ninty nine % of all groundwater supplies and ninty five % of all surface drinking water supplies in a survey of drinking water from U.S. Cities were less than 0.5 ug/L [930]. Exposure to levels of carbon tetrachloride higher than these typical "background" levels is likely to occur only at specific industrial locations where carbon tetrachloride is still used or near chemical waste sites where emissions into air, water, or soil are not properly controlled [930].

W.High (Water Concentrations Considered High):

The median values of positive samples of this compound found in a survey of drinking water from U.S. Cities was 0.3 to 0.7 ug/L [930].

W.Typical (Water Concentrations Considered Typical):

The highest amount of this compound found in a survey of drinking water from U.S. Cities was 16 ug/L [930].

Carbon tetrachloride is found in some drinking water supplies, usually at concentrations less than 0.5 ppb [930]. Analysis of 945 drinking water samples from cities around the United States found detectable levels (less than 0.2 ug/L) in 30 (3.2%) of the samples [930]. The highest value reported was 16 ug/L, and the median value of the positive samples ranged from 0.3 to 0.7 g/L in different sample groups [930]. Carbon tetrachloride has also been detected in some private drinking water wells, at levels ranging from 1 to 720 ug/L [930]. Based on a survey of groundwater monitoring data from 479 waste sites, carbon tetrachloride was also detectable in groundwater (concentration not reported) at 32 sites in 9 EPA regions [930]. A survey of data by the National Academy of Sciences (1978) reported a range of carbon tetrachloride concentrations in seawaters of 0.2-0.7 ng/L [930]. Based on analysis of data from the STORET database, carbon tetrachloride was detectable in 12% of 8,858 ambient water samples [930]. The median concentration in all samples was 0.1 ug/L [930].

Information from HSDB [940]:

> Surface Water: at various depths of Lake Zurich, Switzerland, concentrations of approx 25 parts/trillion were measured with no significant variation; Ground Water: levels in the industrial sector near Lake Zurich were reported at levels from 190-3600 parts/trillion and the compound was detected in 4/18 samples. [Giger W et al; Aquatic Poll: Transform Bio Eff pp.101-23 (1978) as cited in USEPA; Health Assessment Document: Carbon tetrachloride p.4-5 (1984) EPA-600/8-82-001F].
>
> Carbon tetrachloride/ ... Detected @ levels higher than those found in raw water, suggesting ... /It/ had leached from pvc pipe. Levels ... Were 52 to 125 times higher than concentration(s) in raw water. [National Research Council. Drinking Water & Health, Volume 4. Washington, DC: National Academy Press, 1981. 66].
>
> SURFACE WATER: Marine - surface 0.12-0.85 parts/trillion carbon tetrachloride, at 300 m depth - 0.15 parts/trillion (1,2,3). Fresh - 0-9 ppb(4-10). 14 heavily industrialized rivers 1-3 ppb, 6 of 204 samples pos(11). Great lakes - 9-47 parts/trillion (12,13). USEPA STORET DATA BASE - 8,858 water samples, 12% pos., median concentration 0.10 ug/L(14). [(1) Singh HB et al; Atmospheric distribution, sources and sinks of halocarbons, hydrocarbons, SF6 and N2O. p. 57 USEPA-600/3-79-107 (1979) (2) Singh HB et al; J Air Pollut Control Assoc 27: 332-6 (1977) (3) Murray AJ, Riley JP;

Nature 242: 37-8 (1973) (4) Ewing BB et al; Monitoring To Detect Previously Unrecognized Pollutants In Surface Waters. p. 72 USEPA-560/6-77-015 (1977) (5) Haberer K, Normann S; Gas-wasserfach: Wasser/Abwasser 120: 302-7 (1979) (6) Ohio R Valley Water Sanit Comm; EPA grant R-804615 (1979) (7) Ohio R Valley Water Sanit Comm; 1977 Mainstream Assessment (1978) (8) Ohio R Valley Water Sanit Comm; 1978-9 Mainstream Assessment (1980) (9) Dreisch FA et al; Survey of Huntington and Philadelphia River Water Supplies For Purgable Organic Contaminates. p. 10-11 USEPA-903/9- 81-003 (1980) (10) Coniglio WA et al; Occurrence Of Volatile Organics In Drinking Water. Briefing (1980) (11) Ohio R Valley Water Sanit Comm; 1980-81 Main Stream Assessment (1982) (12) Kaiser KLE, Valdmanis I; J Great Lakes Res 5: 106-9 (1979) (13) Konasewich D et al; Great Lakes Quality Review Board Report (1978) (14) Staples CA et al Environ Tox Chem 4: 131-42 (1985)].

GROUNDWATER: 3-20 ppb carbon tetrachloride for 27 US cities(1), 5 ppb Netherlands(2). As of June 1984, analyzed for but not found in 1174 community wells and 617 private wells in Wisconsin(3). [(1) Coniglio WA et al; Occurrence Of Volatile Organics In Drinking Water. Briefing (1980) (2) Zoeteman BCJ et al; Chemosphere 9: 231-49 (1980) (3) Krill RM, Sonzogni WC; J Am Water Works Assoc 78: 70-5 (1986)].

DRINKING WATER: 0.1-30 ppb carbon tetrachloride in 181 US cities - surface water source(1), 0.2-13 ppb in 39 US cities - groundwater source(1), 0-190 parts/trillion in 9 homes - Love Canal(2), 135-400 ppb wells in NJ and NY(3), 0-4 ppb - 80 US cities(4). [(1) Coniglio WA et al; Occurrence Of Volatile Organics In Drinking Water. Briefing (1980) (2) Barkley J et al; Biomed Mass Spectrom 7: 139-47 (1980) (3) Burmaster DE; Environ 24: 6-13,33-6 (1982) (4) Symons JM et al; J Amer Water Works Assoc 67: 634-47 (1975)].

RAIN: La Jolla, CA 2.8 parts/trillion, industrial area in England 300 parts/trillion carbon tetrachloride(1). SNOW: Southern and Central California 0.33-0.36 parts/trillion, Alaska 2.2 parts/trillion(1). [(1) Su C, Goldberg ED; Mar Pollut Transfer 1976: 353-74 (1976)].

Effluents Concentrations [940]:

Wastewater from a wastewater treatment plant, Los Angeles county CA; 12-16 ppb. [Young; Ann Rep S CA.

Coastal Water Res, 1978].

Industries with mean concentrations >90 ppb - non-ferrous metals manufacturing, paint and ink formulation, rubber processing, mean range 90-700, max range 1700-1800(1). USEPA STORET DATA BASE - 1,343 effluent samples 5.5% pos., median concentration <5.0 ug/L(4). Detected in leachate from a municipal landfill in southern California, max concentration 11 ppb(2). Detected in leachate from Occidental Chemical Co landfill in Niagara Falls, NY(3). [(1)USEPA; Treatability Manual USEPA-600/282-001A p. I.12.4-1 to 4-5 (1981) (2) Wood JA, Porter ML; J Air Pollut Control Assoc 37: 609-15 (1987) (3) Talian SF et al; pp. 525-42 in Proc AWWA Water Quality Technol Conf. Harrisburg PA: Gannett Fleming Water Resourc Eng (1986) (4) Staples CA et al; Environ Tox Chem 4: 131-42 (1985)].

Environmental accumulation: ... Has been found ... Effluent water from commercial manufacturing sources and sewage treatment plant effluent water taken from 43 sites in us and europe. [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 375 (1979)].

Release of tetrachloromethane to the environment (water) in 1978: total, 360 kkg (production, 50 kkg; grain fumigant, < 1 kkg; intermediate, < 1 kkg; identified solvent uses, 110 kkg; miscellaneous, 200 kkg). /From table/ [Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 3-3].

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: 3.52E+4 ug/L LEC

> Older Reference [446]: Freshwater Acute Criteria: Insufficient data to develop criteria. Lowest Observed Effect Level: 35,200

Chronic Freshwater: None

Acute Marine: 5.0E+4 ug/L LEC

> Older Reference [446]: Marine Acute Criteria: Insufficient data to develop criteria. Lowest Observed Effect Level: 50,000 ug/L [446].

Chronic Marine: None

Reference: 45 FR 791318 (11/28/80)

Contact: Criteria and Standards Division / OWRS / (202)260-1315

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.

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].

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 56-23-5 (CARBON TETRACHLORIDE), the benchmarks in ug/L are:

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

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

SECONDARY ACUTE VALUE: 4090

SECONDARY CHRONIC VALUE: 229

LOWEST CHRONIC VALUE - FISH: > 1970

ESTIMATED LOWEST CHRONIC VALUE - DAPHNIDS: 5580

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

LOWEST CHRONIC VALUE - AQUATIC PLANTS: No information found.

LOWEST TEST EC20 - FISH: 65

LOWEST TEST EC20 - DAPHNIDS: No information found.

W.Plants (Water Concentrations vs. Plants):

Toxicity Threshold (Cell Multiplication Inhibition Test) Scenedesmus quadricauda (green algae) >600 mg/l (Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 343) [940]

W.Invertebrates (Water Concentrations vs. Invertebrates):

LC50s for Daphnia magna (water flea) are 35 mg/L for both 24- and 48-hr exposures [998].

Toxicity Threshold (Cell Multiplication Inhibition Test) Pseudomonas putida (bacteria) 30 mg/l (Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 342) [940]

W.Fish (Water Concentrations vs. Fish):

The no-observed-effect-concentration for death in Pimephales promelas (fathead minnow) was 37.1 mg/L for a 7-day exposure, and the lowest-observed-effect-concentration (LOEC) for death was 73.2 mg/L also for a 7-day exposure [998].

Information from HSDB [940]:

LC50 Lepomis macrochirus (Bluegill) 125,000 ug/l/96 hr (static unmeasured) [Dawson GW; J Haz Mat 1: 303 (1977) as cited in USEPA; Health Assessment Document: Carbon Tetrachloride p. 6-3 (1984) EPA-600/8-82-001F].

LC50 bluegill 27 mg/l/96 hr (95% confidence limit 23-33 mg/l) & 38 mg/l/24 hr @ 21-23 deg C /conditions of bioassay not specified/ [Buccafusco RJ et al; Bull Environ Contam Toxicol 26: 446 (1981)].

LC50 Menidia beryllina (tidewater silverside) 150,000 ug/l/96 hr. /Static, unmeasured bioassay/ [Dawson GW; J Haz Mat 1: 303 (1977) as cited in USEPA; Health Assessment Document: Carbon Tetrachloride p.6-3 (1984) EPA-600/8-82-001F].

LC50 Limanda limanda 50,000 ug/l/96 hr. /Estimated/ [Pearson CR, McConnell; Proc Roy Soc London Ser B 189 (1096): 305-22(1975) as cited in USEPA; Health Assessment Document: Carbon Tetrachloride p.6-3 (1984) EPA-600/8-82-001F].

LC50 Poecilia reticulata (Guppy) 67 ppm/14 days /Conditions of bioassay not specified/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 343].

LC50 Pimephales promelas (fathead minnow) 41.4 mg/l/96 hr (confidence limit 36.3 - 47.3 mg/l), flow-through bioassay with measured concentrations, 21.7 deg C, dissolved oxygen 7.1 mg/l, hardness 49.2 mg/l calcium carbonate, alkalinity 39.6 mg/l calcium carbonate and pH 6.8. [Geiger D.L., D.J. Call, L.T. Brooke. (eds.). Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales-Promelas). Vol. V. Superior WI:University of Wisconsin-Superior, 1990. 28].

EC50 Pimephales promelas (fathead minnow) 20.8 mg/l/96 hr (confidence limit 18.3 - 23.7 mg/l), flow-through bioassay with measured concentrations, 21.7 deg C, dissolved oxygen 7.1 mg/l, hardness 49.2 mg/l calcium carbonate , alkalinity 39.6 mg/l calcium carbonate, and pH 6.8. Effect: loss of equilibrium. MinnowEC [Geiger D.L., D.J. Call, L.T. Brooke. (eds.). Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales-Promelas). Vol. V. Superior WI:University of Wisconsin-Superior, 1990. 28].

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) 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 56-23-5 (CARBON TETRACHLORIDE), the benchmarks are:

SPECIES	WATER CONCENTRATION (ppm)
Rat (test species)	0.00000
Short-tailed Shrew	205.65000
Little Brown Bat	355.44500
White-footed Mouse	132.90500
Meadow Vole	232.60700
Cottontail Rabbit	110.22000
Mink	114.29500
Red Fox	81.57000
Whitetail Deer	45.64000

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

1995 EPA Region 9 PRG for tap water: 0.17 mg/L [868].

EPA 1996 IRIS database information [893]: [893].

Maximum Contaminant Level Goal: 0 mg/L. [893].

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 carbon tetrachloride is proposed based on carcinogenic effects. Carbon tetrachloride has been shown to be carcinogenic in rats, mice, and hamsters through oral exposure. Hepatocellular carcinomas in several studies have been observed. EPA has classified carbon tetrachloride in Group B2: sufficient evidence in animals and inadequate evidence in humans. [893].

Maximum Contaminant Level (MCL): 0.005 mg/L [893].

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].

Editor's note: modern detection limits are now even lower, 0.05 ug/L (see Laboratory section below).

Ambient Water Quality Criteria for Human Health [893]:

Water & Fish: 4.0E-1 ug/liter [893].

Older reference for human health water quality criteria (10-6 Risk Level for Carcinogens) in ug/L [446]:

Published Criteria for Water and Organisms: 0.4 ug/L.

E-5 risk: 4 ug/l; E-7 risk 0.04 ug/l, EPA 1980 [930].

Fish Only: 6.94E+0 ug/liter [893].

Older reference for human health water quality criteria (10-6 Risk Level for Carcinogens) in ug/L [446]:

Published Criteria for Organisms Only: 6.94.

Reference: 45 FR 791318 (11/28/80) [893].

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

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

[893].

Older Federal Drinking Water Standards [940]:

EPA 5 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)].

State Drinking Water Standards [930,940]:

(AL) ALABAMA 5 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)].

(AZ) ARIZONA 5 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)].

(CA) CALIFORNIA 0.5 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)].

(FL) FLORIDA 3 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)].

(NJ) NEW JERSEY 2 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)].

State Drinking Water Guidelines [940]:

(AZ) ARIZONA 0.27 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)].

(CT) CONNECTICUT 5 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and

Guidelines (11/93)].

(ME) MAINE 2.7 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)].

(MN) MINNESOTA 3 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)].

Clean Water Act Requirements [940]:

The levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10-5, 10-6, and 10-7. The corresponding recommended criteria are 4.0 ug/l, 0.4 ug/l, and 0.04 ug/l, respectively. [USEPA; Quality Criteria for Water 1986: Carbon Tetrachloride (May 1,1986) EPA 440/5-86-001].

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

Drinking water levels are generally low (ppb) unless contaminated (IARC; Monographs on the evaluation of carcinogenic risk of chemicals to man 1: 53-5, 1972] [940].

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

Sed.Low (Sediment Concentrations Considered Low):

No information found.

Sed.High (Sediment Concentrations Considered High):

Carbon tetrachloride has been found in water or soil at about 22% of the waste sites investigated under Superfund, at concentrations ranging from less than 50 to over 1,000 ppb [930].

Sed.Typical (Sediment Concentrations Considered Typical):

Based on information from the STORET database, carbon tetrachloride was detected in 0.8% of sediment samples across the United States [930]. The median concentration of all samples was less than 5 mg/kg dry weight [930].

USEPA STORET DATA BASE - 361 sediment samples, 0.8% pos., median concentration(s) <5.0 mg/kg dry weight basis (Staples CA et al; Environ Tox Chem 4: 131-42, 1985) [930,940]

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

Sed.General (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 56-23-5 (CARBON TETRACHLORIDE), the benchmark is):

ESTIMATED EQUIVALENT SEDIMENT QUALITY CRITERION at 1% Organic Carbon: 1.29

Note: Marine sediments high in organic matter tended to have higher concentrations of carbon tetrachloride than did sediments with lower organic matter [930].

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):

Marine sediments high in organic matter tended to have higher concentrations of carbon tetrachloride than did sediments with lower organic matter [930].

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):

Carbon tetrachloride has been found in water or soil at about 22% of the waste sites investigated under Superfund, at concentrations ranging from less than 50 to over 1,000 ppb [930].

Soil.Typical (Soil Concentrations Considered Typical):

Very low background levels of carbon tetrachloride are found in air, water, and soil because of past and present releases [930].

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):

No information found.

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 = 5 mg/kg for ingestion pathway [952].

SSL = 0.0 mg/kg for inhalation pathway [952].

SSL = 0.003 to 0.07 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: 0.47 mg/kg wet wt.
Industrial Soil: 1.1 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:

0.03 mg/Kg dry weight [903].

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

The composition of the soil organic matter and the water content of the soil may also affect sorption of carbon tetrachloride [930]. Experimentally determined Koc values for sorption of carbon tetrachloride on soils with organic carbon content of 1.49% and 0.66% were 143.6 and 48.89 (log Koc = 2.16 and 1.69), respectively [930]. The retardation factor of carbon tetrachloride in breakthrough sampling in groundwater ranged from 1.4 to 1.7, indicating that soil adsorption is a relatively minor fate process [930]. Adsorption Coefficient (Koc) -- Is the ratio of the amount of a chemical adsorbed per unit weight of organic carbon in the soil or sediment to the concentration of the chemical in solution at equilibrium [930].

Most carbon tetrachloride released to soil is expected to volatilize repidly due to its high vapor pressure (91.3 mmHg at 20 C) [930]. A fraction of the carbon tetrachloride remaining in the soil may adsorb to the soil organic matter, based on a calculated soil sorption coefficient of 110 (log K oc of 2.04) [930]. Nevertheless, carbon tetrachloride is expected to be moderately mobile in most soils, depending on the organic carbon content, and leaching to groundwater is possible [930].

No studies were located on the degradation of carbon tetrachloride in soil or sediment [930]. Based on the estimated aqueous aerobic biodegradation half-life of carbon tetrachloride the half-life of carbon tetrachloride in soil is estimated to be 6-12 months [930].

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:

/Carbon tetrachloride/ residue in wheat germ with a high fat content was found to be less than 50% of that found in bran (Hayes, Wayland J., Jr. Pesticides Studied in Man. Baltimore/ London: Williams and Wilkins, 1982. 145) [940]

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:

Fish/Seafood Concentrations [940]:

Mollusks - 2-114 ppb, fish - 3-209 ppb, with medians of 11 and 19 ppb respectively(1). USEPA STORET DATA BASE - 97 biota samples, 0% pos., detection limit 0.05 mg/kg wet weight basis(2). [(1) Dickson AG, Riley JP; Mar Pollut Bull 7: 167-9 (1976) (2) Staples CA et al; Environ Tox Chem 4: 131-42 (1985)].

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):

No information found.

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

Rainbow trout were given diets containing 3200 and 12800 ppm carbon tetrachloride. 4 Out of 44 at the lower dose level and 3 out of 34 at the higher dose level developed hepatomas after 20 mo, whereas no tumors were found in the controls (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. V1 56, 1972) [940]

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

Fish/Seafood Concentrations [940]:

Mollusks - 2-114 ppb, fish - 3-209 ppb, with medians of 11 and 19 ppb respectively(1). USEPA STORET DATA BASE - 97 biota samples, 0% pos., detection limit 0.05 mg/kg wet weight basis(2). [(1) Dickson AG, Riley JP; Mar Pollut Bull 7: 167-9 (1976) (2) Staples CA et al; Environ Tox Chem 4: 131-42 (1985)].

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 56-23-5 (CARBON TETRACHLORIDE), the benchmarks are):

SPECIES	NOAEL (mg/kg/day)	FOOD CONCENTRATION (ppm)
Rat (test species)	16.00000	0.00000
Short-tailed Shrew	45.24300	75.40500
Little Brown Bat	56.87100	170.61400
White-footed Mouse	39.87200	257.99200
Meadow Vole	31.71900	279.12900
Cottontail Rabbit	10.65500	53.94700
Mink	11.31500	82.59300
Red Fox	6.88800	68.88200
Whitetail Deer	2.98900	97.05000

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

3 ppm milk from cows treated with veterinary medication containing carbon tetrachloride (IARC; Monographs on the evaluation of carcinogenic risk of chemicals to man 1: 55, 1972) [940]

Tis.Human:

A) Typical Concentrations in Human Food Survey Items:

Estimates of carbon tetrachloride residue levels in treated grain varied as a function of fumigation conditions and the amount of aeration after fumigation, but values of 1-100 mg/kg were typical [930]. 1987; Letkiewicz et al [930]. 1983; Lynn and Vorches 1957; McMahon 1971) [930].

Levels in finished food prepared from fumigated grains were considerably lower, with typical concentrations below 0.1 mg/kg [930]. Carbon tetrachloride was detected in 44 of 549 food items at an average concentration of 0.031 mg/kg in a Food and Drug Administration (FDA) survey [930]. However, carbon tetrachloride is no longer used for this purpose in the United States, so exposure from this source is no longer of concern, but certain foods may absorb small amounts of carbon tetrachloride from the air during processing [930]. Carbon tetrachloride does not appear to occur in significant quantities in most other foods [930].

Food Survey Results [940]:

> The USEPA Pesticide Labs detected 0.005 to 2.61 mg/kg CCl_4 in flour from 11 US cities with an average level of 0.051 mg/kg. [USEPA; Health Assessment Document: Carbon Tetrachloride p.4-10 (1984) EPA-600/8-82-001F].
>
> Carbon tetrachloride levels of 0.0002 to 0.0003 mg/kg were detected in flour. However bread and biscuits made from this flour contained undetectable levels of carbon tetrachloride. [Bondi A, Alamot E; Evaluation of some pesticide residues in food, WHO Pesticide Residues Series, No 1, 1972].
>
> Carbon tetrachloride was detected at levels of 76 to 115 mg/kg in wheat, 10 to 21 mg/kg in flour, 28 to 39 mg/kg in oats, and 43 to 88 mg/kg in bran that had been fumigated with the recommended fumigant dosages. [Lynn GE, Vorches Jr, eds; J Assoc Ag Chem 52: 800 (1957) as cited in USEPA; Health A ssessment Document: Carbon Tetrachloride p.4-11 (1984) EPA-600/8-82-001F].
>
> Carbon tetrachloride was detected at 200 to 400 mg/kg in wheat and corn after application of a fumigant. Residual carbon tetrachloride decr to 1-10 mg/kg 6 months after fumigation. By 12 months post-fumigation, the wheat and corn contained a max of 4.7 mg/kg carbon tetrachloride. [Scudamore KA, Heuser SG; Pestic Sci 4: 1-12 (1973) as cited in USEPA; Health Assessment Document: Carbon tetrachloride p.4-11 (1984) EPA-600/8-82-001F].
>
> A range of 3-18 ng/g in fats, fruits and

vegetables, meat, tea and bread with oils and fats being at the high end of range (16-18 ng/g)(1). Possible residues in grain products - 50 ppm (raw cereals), 10 ppm (milled cereals), and 0.05 ppm (cooked cereal products)(2). 7 samples of grains had a residues range of 2.9-20.1 ppm(3). Residues detected in grains (wheat, corn, oats) ranged between 0.003-49 ppm and intermediate grain-based foods (corn muffin mix, cake mix, flour, etc) ranged between 0.0-100 ppb(4). Detected in a variety of table ready food items (ppb): chocolate chip cookies, 1.3; plain granola, 3.4; butter, 6; cheddar cheese, 1.1; peanut butter, 0.44; evaporated milk, 0.10; boiled green peas, 0.18; fried, breaded shrimp, 0.88; cooked pork sausage, 0.44; and frozen fried chicken dinner, 0.76(5). [(1) McConnell G et al; Endeavor 34: 13-8 (1975) (2) IARC; Monographs on the evaluation of carcinogenic risk of chemicals to man 1: 54 (1972) (3) McMahon BM; J Assoc Off Anal Chem 54: 964-5 (1971) (4) Heikes DL, Hopper ML; J Assoc Off Anal Chem 69: 990-8 (1986) (5) Heikes DL; J Assoc Off Anal Chem 70: 215-26 (1987)].

Three ppm milk from cows treated with veterinary medication containing carbon tetrachloride(1). [(1) IARC; Monographs on the evaluation of carcinogenic risk of chemicals to man 1: 55 (1972)].

See also: ATSDR [930].

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 1996 IRIS Database [893]:

Crit. Dose: 0.71 mg/kg-day [Study 1 NOAEL(adj)] UF: 1000 MF: 1

RfD: 7E-4 mg/kg-day Confidence: Medium

Average Daily Intake [940]:

Air intake - (assume 0.1-4 ppb) 12-511 ug; Water intake - (assume range of 0.1-30 ppb) - 0.2-60 ug; Food - insufficient data. (SRC)].

Acceptable Daily Intake [940]:

0.025 mg/l /Adjusted acceptable daily intake

(AADI)/ [USEPA; Drinking Water Criteria Doc: Carbon Tetrachloride p.viii (1985)].

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

Detected not quantified in 5 of 6 samples of mother's milk in 4 urban sites - Pennsylvania - 1, New Jersey - 2, Louisiana - 1(1). In blood from workers exposed to carbon tetrachloride during production of chlorinated rubbers for road paint (in Italy), mean concentration(s) 3.3-6.5 ug/L(2). Detected in expired air of carefully selected normal, healthy human subjects (non-smokers), 387 samples from 54 subjects, 29.7% samples pos., mean concentration 1.4 ng/L(3). USEPA TEAM Study - New Jersey, 322 breath samples Fall 1981, weighted median 0.69 ug/cu m, 148 breath samples Summer 1982 - 0.17 ug/cu m(4). [(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28:322-8 (1982) (2) Brugnone F et al; pp. 575-8 in Developments in the Science and Practice of Toxicology; Hayes AW et al eds: Elsevier Science (1983) (3) Krotoszynski BW et al; J Anal Tox 3: 225-34 (1979) (4) Wallace LA et al; Environ Res 43: 290-307 (1987)]

Tis.Misc. (Other Tissue Information):

The most convenient way is simply to measure carbon tetrachloride in exhaled air, but carbon tetrachloride can also be measured in blood, fat, or other tissues [930].

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

There is little tendency for carbon tetrachloride to bioconcentrate in aquatic or marine organisms [930]. Reported log bioconcentration factors (log BCFs) were 1.24 and 1.48 in trout and bluegill sunfish, respectively [930]. However, the log octanol/water partition coefficient (log K_{oc}) of 2.64 for carbon tetrachloride suggests that bioaccumulation is at least possible under conditions of constant exposure and may occur in occupational settings or in people living at or near hazardous waste sites [930]. No data were located on the biomagnification of carbon tetrachloride [930]. However, since most animals readily metabolize and excrete carbon tetrachloride following exposure biomagnification is not expected [930].

Carbon tetrachloride has a low potential to bioconcentrate(1). Log of the bioconcentration factor in trout is 1.24(1,2), in bluegill sunfish - 1.48(3). [(1) Neely WB et al; Environ Sci Technol 8: 1113-5 (1974) (2) Veith GD et al; J Fish Res Board Can 36: 1040-8 (1979) (3) Barrows ME et al; Dyn Exp Hazard Assess Toxic

Chem Ann Arbor MI: Ann Arbor Science p 379-92, (1980)] [940].

Bioconcentration factor predicted from water solubility = 14 (calculated); bioconcentration factor = 18 (experimental). /From table (Kenaga EE; Ecotoxicology and Environmental Safety 4: 26-38 (1980) [940].

Interactions:

Information from HSDB [940]:

Concurrent treatment of mammals with carbon tetrachloride & DDT ... Increases susceptibility (approx 10 fold) to carbon tetrachloride toxicity. [Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 865].

Susceptibility to carbon tetrachloride poisoning is enhanced by ... /Simultaneous/ use of alcohol ... Poor nutritional status & perhaps ... Calcium deficiency ... [Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-102].

Substances which cause an increase in activity of the microsomal drug metabolism system (such as ... Barbiturates ...) Increased toxicity of carbon tetrachloride as shown by biochemical liver function changes. [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. 109].

20 Days oral admin of hexachlorobenzene (30 mg/kg in corn oil, 7 doses), polybrominated biphenyls (5 mg/kg daily) or polychlorinated biphenyls (10 mg/kg daily) increased carbon tetrachloride-induced (0.00, 0.03, 0.25, Or 2.00 Ml/kg, ip) growth retardation, renal tubular functional impairment, & hepatocellular necrosis in male rats. [KLUWE WM ET AL; TOXICOL 23: 321 (1982)].

In male sprague-dawley-jcl rats oral dose of 1250 mg/kg dipyridamole lowered serum enzyme activity & reduced significantly the area % of hepatic necrosis & hydropic degeneration induced by 1.0 Ml/kg carbon tetrachloride, oral. [KAST A ET AL; EXP PATH 21: 123 (1982)].

Isopropanol pretreatment (2.5 Ml/kg in 25% aq soln by gavage) enhanced hepatotoxicity of carbon tetrachloride (0.1 Or 2.0 Mmol/kg) in rats, selectively enhanced the rate & total extent of carbon dioxide & chloroform metabolite exhalation. [REYNOLDS ES ET AL; LIFE SCI 31 (7): 661 (1982)].

Treatment of rats with a single dose of 5 mg lysineacetylsalicylic acid/kg given 6 hr after carbon tetrachloride challenge increased hepatic injury; when given 12 hr afterward, it gave protection against carbon tetrachloride. Trials with indomethacin gave similar results. Prostacyclin injected ip 30 min before and 6 hr after carbon tetrachloride produced significant protection against liver necrosis. [GUARNER F ET AL; ADV PROSTAGLANDIN, THROMBOXANE, LEUKOTRIENE RES 12: 75-82 (1983)].

Reserpine, carbon disulfide and diethyldithiocarbamate diminish toxic effects of carbon tetrachloride on the liver. [Douglas BH, Clower BR; Am J Obstet Gynecol 102: 236 (1980)].

Chlorpromazine prevented liver necrosis from carbon tetrachloride in short-term rat experiments without affecting lipid peroxidation or binding of carbon tetrachloride reactive metabolites. [Marzi A et al; Toxicol Appl Pharmacol 52: 82 (1980) as cited in USEPA/ECAO; Atlas Doc for: Carbon Tetrachloride p.28 (1981)].

Carbon tetrachloride did not effect the mutagenicity of cyclophosphamide when tested in vitro with Salmonella typhimurium strains G46 and TA1950. [Kissling M, Speck B; Helv Med Acta 36: 59-66 (1971) as cited in Fishbein L; Potential Indust Carcins & Mutagens p.166 (1977) USEPA 50/ 5-77-005].

Thuringer Gensen rabbits pretreated with 0.1% sodium phenobarbital in drinking water (duration not specified) ... hepatic microsomes were isolated from the pretreated rabbits and incubated anaerobically with (14)C carbon tetrachloride for 60 min. The amount of isotope binding increased steadily during incubation to 3,200 mg of (14)C kg/lipid. 80-85% of the (14)C in this fraction was bound to phospholipids; 48.9% of the (14)C-bound phospholipid was lecithin, 26.0% was cephalin, 10.7% was phosphatidylinositol, 8.8% was sphingomyelin, and 5.6% was phosphatidylserine. Under these incubation conditions, (14)C carbon tetrachloride bound to mitochondrial protein only in the presence of NADPH. [Uehleke H, Werner TH; Arch Toxicol 34: 289-308 (1975)].

Pretreatment of rats with 0.1% phenobarbital in drinking water for 8 days or with 20 mg of 3-methylcholanthrene ip for 3 days induced a greater than 2-fold increase in hepatic microsomal cytochrome p450 levels, but enhanced (14)C carbon tetrachloride binding to microsomal protein by about 50% and to lipid by 8-14%. Pretreatment with cobalt chloride 40 mg/kg ip for 2 days reduced the p450 level by about 40% and the incorporation of (14)C into protein by about 30%. 14C incorporation into lipids was not altered. Hepatic microsomes from 18 hr old rats contained 0.32 nmole of p450 per mg of protein and bound 240 mg of (14)C carbon tetrachloride per kg of protein in 10-min. Rats at 32 days of age contained 1.05 n mole of p450 per mg of protein and bound 106 mg of (14)C per kg of protein. [Uehleke H, Werner TH; Arch Toxicol 34: 289-308

(1975)].

Simultaneous administration of 1,400 mg of carbon tetrachloride by gavage once weekly and 0.025% 2,7-bis(acetamido)fluorene for 8 weeks resulted in an increased incidence in hepatomas as compared to that of animals not exposed to carbon tetrachloride. [Takizana S et al; Gann 66: 603-14 (1975)].

Feeding rats a diet containing 0, 40, or 200 IU/kg alpha-tocopherol acetate (vitamin E) for a minimum of 4 weeks produced a marked decrease in basal lipid peroxidation (measured as pentane production) of approximately 60% at the 40 IU/kg and 75% at the 200 IU/kg level. Ip administration of 480 mg/kg carbon tetrachloride produced a five-fold increase in lipid peroxidation in vitamin-E-deficient animals. At 40 IU/kg of vitamin E, the response decreased approximately 36% at both 4 and 5 weeks. At 200 IU/kg of vitamin E, the response was decreased by 44%. [Sagai M, Tappel AE; Toxicol Lett 2: 149-55 (1978)].

Pretreatment of rats with 4,000 mg/kg carbon tetrachloride by gavage 42 or 60 hours prior to a single dose of dimethylnitrosamine (20 mg/kg) resulted in an increased incidence of liver and kidney neoplasms at 12 months. If the pretreatment of rats with carbon tetrachloride was more than 60 hours prior to administration of dimethylnitrosamine, the incidence of kidney neoplasms decreased while that of liver neoplasms increased further. [Pound AW et al; Br J Cancer 27: 451-9 (1973)].

Pretreatment of mice with 80 mg of carbon tetrachloride sc one day prior to administration of 10 or 20 mg of n-butylnitrosourea by gavage resulted in the induction of neoplasms in 12 of 28 mice as compared to 1 of 18 mice not given carbon tetrachloride. [Takizawa S et al; Gann 66: 603-14 (1975)].

Triamcinolone and progesterone have been noted to potentiate carbon tetrachloride's effect on the liver. [Tuchweber B, Kovacs K; Arch Toxikol 27: 159-67 (1971)].

A higher mortality and more extensive liver necrosis in dogs was found when an /oral administration/ of 4 ml of 95% ethyl alcohol with 4 ml carbon tetrachloride than with carbon tetrachloride given alone. The enhancing effect of alcohol did not occur when the carbon tetrachloride administered was 0.05 or 0.10 mg/kg. [NIOSH; Criteria Document: Carbon Tetrachloride p.61 (1975) DHEW Pub. NIOSH 76-133].

Either pretreatment or concomitant admin to rats of trichloroethylene or chloroform markedly potentiated the hepatotoxicity of ... carbon tetrachloride. Chloroebenzene produced a marginal interactive effect (slightly enhanced carbon tetrachloride toxicity). ... [NTP; Fiscal Year 1986 Annual Plan p.134 (1986) NTP-86-086].

Isopropanol and ethanol may potentiate carbon tetrachloride toxicity in humans. [USEPA; Health Assessment Document: Carbon Tetrachloride p.14-10 (1984) EPA-600/8-82-001F].

Ethanol consumption and high fat diets greatly enhance carbon tetrachloride uptake. [NAS; Nonfluorinated Halomethanes in the Environment: Carbon Tetrachloride p.280 (1978)].

Rats were treated orally twice weekly for 12 weeks with acetone (25 mmol/kg in corn oil) or corn oil alone (10 ml/kg) or carbon tetrachloride (5 mmol/kg in corn oil) 18 hr after each pretreatment. Animals were killed after 4, 8, 10, or 12 weeks of treatment. Body weight gain was slower in acetone-treated rats given carbon tetrachloride; 35% died. Compared to corn oil plus carbon tetrachloride-treated rats, acetone plus carbon tetrachloride-treated animals showed lower liver wt-to-body wt ratios and higher kidney wt-to-body wt ratio values. Higher levels occurred for bilirubin concentrations after 4, 8, 10, and 12 wk and for collagen content. No differences were observed in alanine aminotransferase activities between corn oil and acetone-treated rats challenged with carbon tetrachloride. After 10 wk of treatment, acetone plus carbon tetrachloride-treated animals showed a fully developed cirrhosis, whereas a much less severe lesion was observed in corn oil plus carbon tetrachloride-treated rats. Evidence of nephrotoxicity was observed in the acetone plus carbon tetrachloride group as exemplified by elevated BUN values. Apparently, acetone treatment increases the extent of fibrosis and accelerates the appearance of cirrhosis induced by carbon tetrachloride. [Charbonnequ M et al; Hepatology 6 (4): 694-700 (1986)].

The effect of malotilate was studied in carbon tetrachloride-induced chronic liver injury in the rat. Treatment with carbon tetrachloride led to marked necrosis, steatosis, fibrosis, and malotilate (50 mg/kg orally, 5 days per wk given simultaneously with carbon tetrachloride for 6 wk), suppressed the increased of plasma aminotransferase activity and decreased the accumulation of lipid and collagen in the liver. ... Malotilate was able to prevent the increase of hepatic alterations that appeared during the last 3 wk of carbon tetrachloride intoxication. Malotilate can markedly reduce the hepatic disorders induced by chronic carbon tetrachloride intoxication in the rat. [Dumont JM et al; J Hepatol 3 (2): 260-8 (1986)].

The distribution of vitamin A was measured in various body fluids and tissues in rats with carbon tetrachloride induced acute liver injury compared to vehicle treated controls. All rats received 25,000 u of retinol palmitate ip 24 hr prior to study and 50,000 u on the day of the study. Rats with liver injury had significant elevations of unesterified retinol in plasma and saliva, and significant elevations of retinol palmitate in plasma, urine, and kidney. Also, liver disease caused a significant decrease in the liver concentration of retinol palmitate, and significant decrease in the bile and kidney levels of unesterified retinol. These results suggest that redistribution of vitamin A from liver to other areas occurs after acute liver injury in rats. Also, increased levels of vitamin A in urine, saliva, or plasma may be a noninvasive marker for liver injury in man after vitamin A challenge. [Fruncillo RJ et al; Res Commun Chem Pathol Pharmacol 54 (2): 283-6 (1986)].

1,3-Butanediol enhances the hepatotoxic effect of a single small dose of carbon tetrachloride in a dose-related manner. The present study ... predicts the potential hazard of 1,3-butanediol-carbon tetrachloride interaction. Liver damage was modulated in male Sprague-Dawley rats by varying the concentration of the 1,3-butanediol solutions ingested prior to a carbon tetrachloride challenge (0.1 ml/kg, ip). ... 1,3-Butanediol produced a dose-dependent metabolic ketosis observable at dosages between 1.1 and 9.9 g/kg per day given for 7 days. Potentiation of the carbon tetrachloride-induced liver injury was dose-related for the same dosage range; the minimum effective dosage of 1,3-butanediol for potentiation was estimated as 1.1 g/kg per day. ... [Pilon D et al; Toxicology 40 (2): 165-180 (1986)].

Male, Sprague Dawley rats were exposed to chloroform (12, 60 and 120 mg/kg/day) by oral gavage for 3 consecutive days prior to treatment with carbon tetrachloride (16,80 and 160 mg/kg) /by oral gavage/ on day 3. ... Significant interactions between chloroform and carbon tetrachloride were observed /in serum/ for alanine aminotransferase (ALT), aspartate aminotransferase (AST), lactic dehydrogenase (LDH) and creatinine but not for blood urea nitrogen (BUN). ... For dose mixtures containing 1 mmole of chloroform/kg, particularly at the 0.5 amd 1 mmole/carbon tetrachloride/kg levels, there was evidence for a greater than additive response. [USEPA/HERL; Chemical Interactions Among Chlorohydrocarbon Mixtures Found in Wastewater Effluents p.5 (1988) EPA/600/D-88/150].

Uses/Sources:

Carbon tetrachloride is frequently used in the home as a fire extinguisher, dry-cleaning agent, spot remover, or solvent for such products as tar and chewing gum [270].

Major Uses [940]:

Recovery of tin in tin plating waste [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. V1 54 (1972)].

In formulation of petrol additives [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 374 (1979)].

In refrigerants; metal degreasing; prodn of semiconductors [Sax, N.I. and R.J. Lewis, Sr. (eds.). Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 222].

Used to reduce fire hazard in combinations with either carbon disulfide or ethylene dichloride intended as grain fumigants. These mixtures ... Are not approved for fumigation of dry beans, peanuts or peas. /Former uses/ [Farm Chemicals Handbook 1991. Willoughby, OH: Meister, 1991.,p. C-62].

Solvent for rubber cement; cleaning agent for machinery and electrical equipment; in synthesis of nylon-7 and other organic chlorination processes. [Fishbein L; Potential Indust Carcins & Mutagens p.165 (1977) EPA-560/5-77-005].

Use in polymer technology as reaction medium, catalyst; ... in organic synthesis for chlorination of organic compounds; in soap perfumery and insecticides. [Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) PublicationNo. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981. 3].

Industrial solvent for ... cable and semiconductor manufacture. [Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) PublicationNo. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981. 3].

Metal recovery and catalyst regeneration. [Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) PublicationNo. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981. 3].

Chem intermediate for fluorocarbons, esp fluorocarbons 11 & 12 [SRI].

Chem intermediate for pesticides & hexachloroethane [SRI].

Chem intermediate for tetrabromomethane & pyrosulfuryl chloride [SRI].

metal degreasing solvent (former use) [SRI].

Carbon tetrachloride may have small commercial uses as chain transfer agent for making bromotrifluoroethylene polymers and as a catalyst preparation for the commercial isomerization of n-butane to isobutane; also it is used in plasma etching gases for etching aluminum in integrated circuits [DCE/NCI; Monograph On Human Exposure To Chemicals In The Workplace: Carbon Tetrachloride p.2-8 (1985)].

As solvent for oils, fats, lacquers, varnishes, rubber waxes, resins; starting material in manuf of organic cmpd; grain fumigant. Pharmaceutic aid (solvent). Formerly used as dry cleaning agent and fire extinguisher. Formerly as antihelmintic (Nematodes). [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 276].

Natural Occurring Sources [940]:

No natural sources are known(1) but ambient levels may not be totally explained by anthropogenic sources(2). [(1) Singh HB et al; Atmospheric distribution, sources and sinks of selected halocarbons, hydrocarbons, SF6 and N2O. pp.65-73 USEPA-600/3-79-107 (1979) (2) Lovelock JE et al; Nature 241: 194-9 (1973)].

Artificial Sources [940]:

In Soil: Carbon tetrachloride occurs due to spills, run-off from agricultural sites, dumping, and through landfill leaching; In Surface Waters: Carbon tetrachloride occurs as a result of industrial and agricultural activities, some may reach surface water through rainfall; In Air: the major source of carbon tetrachloride is industrial emission. The total nationwide emissions of carbon tetrachloride in 1978 from all sources was estimated at 65 million lb (4.5 million lb from production facilities). The primary source of these emissions is solvent application. [USEPA; Health Assessment Document: Carbon tetrachloride pp.4-2 to 4-9 (1984) EPA-600/8-82-001F].

Waste water from iron and steel manufacturing, foundries, metal finishing, paint and ink formulations, petroleum refining and nonferrous metal manufacturing industries contain carbon tetrachloride(1). Its use has been a major contributor to atmospheric concentrations(2-3). [(1) USEPA; Treatability Manual pp. 12.4-1 to 4-5 USEPA-600/2-82-001A (1981) (2) IARC Monographs on the evaluation of carcinogenic risk of chemicals to man 1: 53-60 (1972) (3) Singh HB et al; Atmospheric distributions, sources and sinks of selected halocarbons, hydrocarbons, SF6 and N2O. pp. 65-73 USEPA-600/3-79-107 (1979)].

Forms/Preparations/Formulations:

Information from HSDB [940]:

Used in combination, 80% carbon tetrachloride & 20% carbon disulfide mixture, these two fumigants form one of the most commonly & effectively used liq fumigant formulations. [White-Stevens, R. (ed.). Pesticides in the Environment: Volume 2. New York: Marcel Dekker, Inc., 1976. 298].

Grades or purity: commercial; technical; usp. [U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5].

Granosan: disinfectant composed of 30% carbon tetrachloride and 70% ethylene dichloride. [Domenici F; Rass Clin-Sci 31: 70-3 (1955) as cited in NIOSH; Criteria Document: Ethylene Dichloride (1,2-Dichloroethane) p.28 (1976) DHEW Pub. NIOSH 76-139].

Grades: Technical; CP /Chemically pure: a grade designation signifying a minimum of impurities, but not 100% purity/; Electronic [Sax, N.I. and R.J. Lewis, Sr. (eds.). Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 223].

Carbon tetrachloride + carbon disulfide; carbon tetrachloride + ethylene dibromide + ethylene dichloride ... [Worthing, C.R. and S.B. Walker (eds.). The Pesticide Manual - A World Compendium. 8th ed. Thornton Heath, UK: The British Crop Protection Council, 1987. 133].

AR, Spectr AR, ACS reagent, Spectrophotometric, NF grade [Chemcyclopedia 1987 p.267].

Technical ACS grade [Kuney, J.H. (ed.). Chemcyclopedia 90. Washington, DC: American Chemical Society, 1990. 59].

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

Practically insoluble in water, carbon tetrachloride forms an organic phase more dense than the aqueous phase [270].

Other Information on Solubilities [940]:

Miscible with alcohol, benzene, chloroform, ether, carbon disulfide, petroleum ether, oils [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 276] [940].

Sol in acetone [Lide, D.R. (ed). CRC Handbook of

Chemistry and Physics. 72nd ed. Boca Raton, FL: CRC Press, 1991-1992.,p. 3-320] [940].

Soluble in naphtha [ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 109] [940].

In water: 1160 mg/l at 25 deg C & 800 mg/l at 20 deg C [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 341] [940].

Vapor Pressure [940]:

91.3 MM HG @ 20 DEG C [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 372 (1979)].

High vapor pressure (108 torr at 25 C) [Gallant RW; Hydrocarbon Process 45: 161-9 (1966)].

Density/Specific Gravity [940]:

1.5940 @ 20 DEG C/4 DEG C [Lide, D.R. (ed). CRC Handbook of Chemistry and Physics. 72nd ed. Boca Raton, FL: CRC Press, 1991-1992.,p. 3-320].

Octanol/Water Partition Coefficient [940]:

log Kow= 2.62-2.83 [Hansch, C., A. Leo. Substituent Constants for Correlation Analysis in Chemistry and Biology. New York, NY: John Wiley and Sons, 1979. 172].

Henry's Law Constant [940]:

Measured to be 3.04 X 10-2 atm-cu m/mole at 24.8 deg C. [Gossett JM, Environ Sci Tech 21: 202-8 (1987)].

Molecular Weight [940]:

153.24 [Lide, D.R. (ed). CRC Handbook of Chemistry and Physics. 72nd ed. Boca Raton, FL: CRC Press, 1991-1992.,p. 3-320].

Corrosivity [940]:

Liquid carbon tetrachloride attacks some forms of plastics, rubber, and coatings. [Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.)].

Surface Tension [940]:

Liquid-water interfacial tension: 45.0 Dynes/cm; liquid surface tension: 270 dynes/cm [U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5].

Vapor Density [940]:

5.32 (AIR= 1) [Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982. 88].

Viscosity [940]:

1.329 cP at 0 deg C; 0.969 cP at 20 deg C [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. F-39].

Boiling Point [940]:

76.54 DEG C [Lide, D.R. (ed). CRC Handbook of Chemistry and Physics. 72nd ed. Boca Raton, FL: CRC Press, 1991-1992.,p. 3-320 [940]].

It boils at 76.7 deg C (170 deg F) and solidifies at -23 deg C (-9.4 deg F) [270].

Melting Point [940]:

-23 DEG C [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 276].

Color/Form [940]:

Colorless, clear, heavy liquid [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 276].

Odor [940]:

Sweetish, aromatic, moderately strong ethereal; somewhat resembling that of chloroform [U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5].

Other Chemical/Physical Properties [940]:

Conversion factors: 1 PPM = 6.29 MG/CU M @ 25 DEG C, 1 MG/L= 159 PPM [Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 173].

Partition coefficients at 37 deg C for carbon tetrachloride into blood= 2.4; into oil= 361. [Sato A, Nakajima T; Scand J

Work Environ Health 13: 81-93 (1987)].

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

Nearly all carbon tetrachloride released to the environment exists in the atmosphere (73% is released to the atmosphere directly [930]. Most of the carbon tetrachloride released to soil and water evaporates within a few days)[930]. Because carbon tetrachloride does not degrade readily in the atmosphere, significant global transport is expected [930]. Monitoring data revealed that the compound is increasing each year in the atmosphere worldwide [930]. The rate of increase has been estimated to be 25 ppb per year [930]. Although carbon tetrachloride is moderately soluble in water (800 mg/L at 20 C), only about 1% of the total carbon tetrachloride in the environment exists dissolved in surface waters and oceans [930]. This is attributable to the relatively high rate of volatilization of low molecular weight chlorinated hydrocarbons from water [930]. 1975) [930]. Because of this, carbon tetrachloride also tends to volatilize from tap water used for showering, bathing, cooking, and other household uses inside a home [930]. Most carbon tetrachloride released to soil is expected to volatilize repidly due to its high vapor pressure (91.3 mmHg at 20 C) [930]. A fraction of the carbon tetrachloride remaining in the soil may adsorb to the soil organic matter, based on a calculated soil sorption coefficient of 110 (log K_{oc} of 2.04) [930]. Nevertheless, carbon tetrachloride is expected to be moderately mobile in most soils, depending on the organic carbon content, and leaching to groundwater is possible [930]. Marine sediments high in organic matter tended to have higher concentrations of carbon tetrachloride than did sediments with lower organic matter [930]. The composition of the soil organic matter and the water content of the soil may also affect sorption of carbon tetrachloride [930]. Experimentally determined K_{oc} values for sorption of carbon tetrachloride on soils with organic carbon content of 1.49% and 0.66% were 143.6 and 48.89 (log K_{oc} = 2.16 and 1.69), respectively [930]. The retardation factor of carbon tetrachloride in breakthrough sampling in groundwater ranged from 1.4 to 1.7, indicating that soil adsorption is a relatively minor fate process [930]. Retradation factors for carbon tetrachloride measured in a flow through system studying sorption of organics to aquifer materials with very low organic carbon (0.07-0.025%) ranged from 1.10 to 1.46, confirming this conclusion [930].

Summary information from HSDB [940]:

> TERRESTRIAL FATE: Carbon tetrachloride is slightly removed during infiltration of river water into adjacent wells(1). However, carbon tetrachloride is expected to evaporate rapidly from soil due to its high vapor pressure and migrate into ground water due to its low soil adsorption coefficient. No data are available on

biodegradation in soil(SRC). [(1) Zoeteman BCJ; Chemosphere 9: 231-49 (1980)].

AQUATIC FATE: Evaporation from water is a significant removal process (half-life - minutes to hours). Based upon field monitoring data, the estimated half-life in rivers is 3-30 days; in lakes and groundwater, 3-300 days(1). Biodegradation may be important under aerobic or anaerobic conditions, but the data are limited. Adsorption to sediment should not be an important process(SRC). [(1) Zoeteman BCJ; Chemosphere 9: 231-49 (1980)].

ATMOSPHERIC FATE: Carbon tetrachloride is very stable in the troposphere with residence times of 30-50 years. Its main loss mechanism is diffusion to the stratosphere where it photolyzes. It is estimated that <1% of the carbon tetrachloride released to the air is partitioned into the oceans(1). [(1) Galbally IE; Science 193: 573-6 (1976)].

Biodegradation [940]:

Biodegradation in screening tests has been noted(1), but acclimation may be necessary(2). Degradation does occur in 16 days under anaerobic conditions(3). [(1) Tabak HH; J Water Pollut Control Fed 53: 1503-18 (1981) (2) Heukelekian H, Rand MC; J Water Pollut Control Assoc 29: 1040-55 (1955) (3) Bower EJ, Mccarty PL; Appl Environ Microbiol 45: 1286-94 (1983)].

Abiotic Degradation [940]:

Hydrolysis half-life in water is 7000 years at 25 deg C(1). Direct photolysis is not important in the troposphere, but irradiation at higher energies (195-254 NM) such as found in the stratosphere results in degradation(2,3). Carbon tetrachloride is stable in the troposphere with residence time of 30-50 years(2). It does not react significantly with any active species in the atmosphere(5). The half-life for reaction with hydroxyl radicals is >330 years(4). [(1) Mabey W, Mill T; J Phys Chem Ref Data 7: 383-415 (1978) (2) Molina MJ, Rowland FS; Geophys Res Lett 1:309-12 (1974) (3) Davis DD et al; J Phys Chem 79: 11-7 (1975) (4) Cox RA et al; Atmos Environ 10: 305-8 (1976) (5) Galbally IE; Science 193: 573-6 (1976)].

Soil Adsorption/Mobility [940]:

Measured KOC of 71 was reported(1). Estimated retardation factor in breakthrough sampling in groundwater - 1.44-1.8(2,3). Carbon tetrachloride is expected to be highly mobile in soil and only slightly adsorbed to sediment(4,SRC). [(1) Sabljic A; J Agric Food Chem 32: 243-6 (1984) (2) Mackay DM et al; Amer Chem Soc 186th Natl Mtg Preprint Div Environ Chem 23: 368-71 (1983) (3) Goltz MN, Roberts PV; J Cont Hydrology 1: 77-93 (1986) (4) Swann RL et al; Res Rev 85: 17-28 (1984)].

Volatilization from Water/Soil [940]:

High vapor pressure (108 torr at 25 C)(1) suggests rapid evaporation from dry soil surfaces(SRC). Henry's Law Constant for carbon tetrachloride has been measured to be 3.04 X 10-2 atm-cu m/mole at 24.8 deg C(8). This value suggests that carbon tetrachloride would volatilize rapidly from water and moist soil surfaces. Based on this value of Henry's Law Constant the volatilization half-life from a model river 1 m deep flowing 1 m/sec with a wind speed of 3 m/sec has been estimated to be 3.7 hours(6,SRC). Measured half-life of evaporation from water - minutes to hours(2-7). [(1) Gallant RW; Hydrocarbon Process 45: 161-9 (1966) (2) Dilling WL; Environ Sci Technol 11: 405-9 (1977) (3) Chiou CT et al; Environ Inter 3: 231-6 (1980) (4) Smith JH et al; Environ Sci Technol 14: 1332-7 (1980) (5) Mackay D, Yeun ATK Environ Sci Technol 17: 211-7 (1983) (6) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. NY: McGraw-Hill p. 15-12 to 15-32 NY: McGraw-Hill (1982) (7) Roberts PV, Dandliker PK; Environ Sci Technol 17: 484-9 (1983) (8) Gossett JM, Environ Sci Tech 21: 202-8 (1987)].

Absorption, Distribution and Excretion [940]:

Carbon tetrachloride is concn ... In body fat, liver, & bone marrow /in monkeys/. Animal expt indicate that inhaled carbon tetrachloride is excreted over 2- or 3-mo period ... 1/2 Is eliminated unchanged in expired air ... Remainder is exhaled as carbon dioxide & excreted as urea & other metabolites in urine & feces. [Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan].

Distributed to all organs & tissues ... Greatest amt ... In body lipids. [Thienes, C., and T.J. Haley. Clinical Toxicology. 5th ed. Philadelphia: Lea and Febiger, 1972. 149].

Readily absorbed by resp tract, gi tract & skin. [Thienes, C., and T.J. Haley. Clinical Toxicology. 5th ed. Philadelphia: Lea and Febiger, 1972. 148].

Monkeys exposed to (14)C-carbon tetrachloride at 290 mg/cu m for 300 minutes, the concentrations of carbon tetrachloride (calculated from the radioactivity) for various tissues were (expressed as carbon tetrachloride mg/100 g of tissue): fat 2.46, liver 0.94, bone marrow 0.93, blood 0.31, brain 0.30, kidney 0.23, heart 0.14, spleen 0.10, muscle 0.06, lung 0.04, and bone 0.04. [McCollister DD; J Pharmacol Exp Ther 102: 112-24 (1951) as cited in USEPA, Office of Drinking Water; Criteria Document: Carbon Tetrachloride p.IV-5 (1982) Contract No. 2-813-03-644-09].

Beagle dogs exposed to 94,500 mg/cu m of carbon tetrachloride by inhalation for 475 minutes; blood concentration of carbon tetrachloride reached a maximum of 31.2 - 34.3 mg/100 cc (0.20 - 0.22 millimole %) after approximately 300 minutes of exposure and remained at that level for the duration of the exposure. Tissue concentrations of carbon tetrachloride (expressed per 100 g of tissue) were: brain 66 mg, heart 36 mg, liver 36 mg, and blood 34 mg. [Von Oettingen WF et al; Arch Int Pharmacodyn 81: 17-34 (1950) as cited in USEPA, Office of Drinking Water; Criteria Document (Final Draft): Carbon Tetrachloride p.IV-3-IV-5 (1982) Contract No. 2-813-03-644-09].

Five rabbits given carbon tetrachloride (1 ml/kg body weight) as a 20% (v/v) soln in olive oil by stomach tube were sacrificed 6, 24, and 48 hours after treatment. From GC/ECD analysis, 6 hr samples showed: (per kg of tissue) 787 + or - 289 mg in fat, 96 + or - 11 mg in liver, 21 + or - 12 mg in muscle, and 20 + or - 13 mg in kidney. By 48 hours, these concentrations had dropped to 45 + or - 12 mg in fat, 4 + or - 0.1 mg in liver, and 0.3 mg in kidney and muscles. [Fowler JSL; Br J Pharmacol 37: 733-7 (1969) as cited in USEPA, Office of Drinking Water; Criteria Doc (Final Draft): Carbon Tetrachloride p.IV-5 (1982) Contract No. 2-813-03-644-09].

Rainbow trout were exposed to 10, 40, 60, and 80 mg/kg or (14)C-labeled carbon tetrachloride in water for 2, 4, 6, and 8 hr. After exposure, the concentration(s) of (14)C was highest in the fat, with lower levels in the liver, heart, and gills, and lowest levels in the muscles. [Statham CN, Lech JJ; Toxicol Appl Pharmacol 37: 173 (1976)].

The rate of absorption through the lung decreases gradually with the duration of the exposure and finally reaches an equilibrium. [NAS; Nonfluorinated Halomethanes in the Environment: Carbon Tetrachloride p.279 (1978)].

The rate of absorption of carbon tetrachloride through the gastrointestinal tract is greatly affected by the diet. ... Most absorbed carbon tetrachloride is excreted promptly. [NAS; Nonfluorinated Halomethanes in the Environment: Carbon Tetrachloride p.280 (1978)].

Laboratory and/or Field Analyses:

Detection Limits for this carbon tetrachloride: For optimum risk or hazard assessment work, volatile compound lab methods with very low detection limits [such as EPA Method 8260 modified for Selective Ion Mode (SIM) Enhanced Detection Limits], GC/HSD, or other rigorous methods should be used. Ideally, the detection limit should be at least 10 times higher than the comparison benchmark or criteria [676]. In concert with need to compare values with low benchmark concentrations, the regulatory requirements of certain States, and the capabilities of better labs, detection limits should be as low as possible to avoid false negatives.

Water Detection Limits:

When drinking water is involved, the EPA goal is zero and the detection limit should be no higher than 0.05 ppb, the detection limit routinely used by the USGS (For water, the USGS uses detection limits of 0.05 ug/L for this VOC (Brooke Connor, USGS Water Quality Lab, Denver, Personal Communication, 1996). Sometimes the lowest detection levels are not needed and others may be used:

Wisconsin requires a detection limit of 0.5 ug/L for all VOCs [923]. For NPDES permit applications using EPA method 601 for purgeable halocarbons, EPA specifies a water detection limit of 0.12 ug/L for this compound (40 CFR, Part 136, Appendix A, Table 1) [1010].

Detection Limits for Solids:

Soil, sediment, and tissue detection limits can be as low as 1.2 ug/kg (ppb) using GC/HSD (halogen specific detectors [930]. In cases where data are not being compared to the lower benchmarks. solids detection levels should be no higher than 25 ppb [913] in soil, sediment, or tissue.

In the past, many methods have been used to analyze for this compound [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. 1995. Test methods for evaluating solid waste, physical/chemical methods, SW-846, EPA Office of Solid Waste and Emergency Response, EPA, Washington, D.C. [1013]. Available from NTIS.

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. RCRA (SW-846) methods tend to include provisions for using the specified method or something better, whereas the CERCLA CLP methods tend to require things done exactly per contract specifications. 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 other "standard protocols" (Roy Irwin, Park Service, Personal Communication, 1997, based on conversations with various EPA and lab staff).

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].

Since they are designed for highly contaminated superfund sites, the CERCLA (CLP) methods typically have higher detection limits than many other EPA standard methods and are thus less appropriate for use in baseline assessments of very clean areas or for use in analyzing environmental concentrations for comparison with low-concentration criteria or benchmarks. EPA (CERCLA) publishes various Contract Laboratory Program (CLP) methods documents periodically, with information available from EPA, NTIS, and the internet. A few past examples (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.

Holding Times:

Water Samples: According to EPA protocols for NPDES permits, the maximum 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].

Containers:

Both EPA and APHA (Standards Methods Book) recommend glass containers for the collection of organic compounds [141,1010,1013]. 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). EPA specifies the use of teflon lined caps and teflon lined cap septums in glass vial containers for water samples of volatiles (VOCs and purgeable halocarbons such as the common organic solvents) [1010]. No headspace is allowed [1010,1013]. 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 EnCore (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).

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).

Field Protocols:

Standard field collection method protocols are published by the Fish and Wildlife Service, DOE, the USGS, NOAA, and EPA [1017]. 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 is becoming more detailed [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 methods typically include recommendations that grab samples rather than composites be utilized for organics, and require the proper cleaning of collection bottles and collecting gear for both volatile and semi-volatile organics [1010,1013]. 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]. 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] [1018].

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 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. In fact, as mentioned in the disclaimers at the top of this entry, 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].

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]. The basics of these 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.

Drinking water methods listed in 1996 EPA IRIS database [893]:

Monitoring Requirements

All systems to be monitored for four consecutive quarters; repeat monitoring dependent upon detection and vulnerability status and system size.

Analytical Methods

Gas chromatography (EPA 502.1, 502.2, 503.1); gas chromatographic/mass spectrometry (EPA 524.1, 524.2).

Misc. Notes on Lab Methods from the ATSDR [930]:

BIOLOGICAL MATERIALS: Separation of carbon tetrachloride from biological samples may achieved by headspace analysis, purge-and-trap collection from aqueous solution or slurry samples, solvent extraction, or direct collection on resins [930]. Headspace analysis offers speed, simplicity, and good reproducibility, but partitioning of the analyte between the headspace and the sample matrix is dependent upon the nature of the matrix and must be determined separately for each different kind of matrix [930]. Purge-and-trap collection is well adapted to biological samples such as blood or urine that are soluble in water [930]. 1985a; Peoples et al [930]. 1979), and is readily adapted from techniques that have been developed for the analysis of carbon tetrachloride in water and wastewater [930]. For water- insoluble materials, the purge-trap approach is complicated by uncertainty of partitioning the analyte between sample slurry particles and water [930]. Historically, diethyl ether has been a widely used solvent for the extraction of volatile components from biological fluids [930]. Homogenization of tissue with the extractant and lysing of cells improves extraction efficiency [930]. When, as is often the case, multiple analytes are being determined using solvent extraction, selective extraction and loss of low-boiling compounds can cause errors [930]. Highly purified solvents have largely eliminated problems with solvent impurities, although high costs, solvent toxicities, and restrictions on spent solvent disposal must be considered [930]. Supercritical fluid extraction using pure carbon dioxide or carbon dioxide with additives offers some exciting potential for the extraction of organic analytes such as carbon tetrachloride from biological samples [930]. Analytical methods for the determination of carbon tetrachloride in biological samples are summarized [930].

ENVIRONMENTAL SAMPLES The basic method for collection of carbon tetrachloride from the ambient atmosphere is adsorption on a solid phase, followed by removal by thermal or solvent elution for subsequent analysis [930]. One of the most common adsorbents for carbon tetrachloride is Tenax GC [930]. Using Tenax adsorbent, standard air containing 1.15 parts per billion by gas volume (ppb) of carbon tetrachloride was determined with biases of -23.0%, -34.7%, -50.0%, and -69.2% at collection volumes of 10, 20, 38 and 76 L of air, respectively [930]. Citing these large negative biases even when the sampled volume was less than 10% of the breakthrough volume, these authors conclude that Tenax is not suitable for quantitative sampling for carbon tetrachloride [930]. For occupational monitoring of carbon tetrachloride in air, NIOSH (1984) recommends samplers containing activated carbon [930]. The adsorbed carbon tetrachloride is extracted from the activated carbon with carbon disulfide, then determined by GC/FID [930]. Studies have been conducted to improve analytical methods for detection of low level volatile organic compounds [930]. Methods have been evaluated that do not require the use of sorbents; thereby, reducing associated uncertainties due to their adsorption/desorption efficiencies [930]. The use of cryogenic preconcentration techniques to increase the sample amount of trace volatile toxic organic compounds in a gas matrix for analysis by GC has been evaluated [930]. The authors revealed that a linear multipoint calibration range from 1 to 15 ppb can be obtained by using a single standard, cryogenic trapping, a constant flow rate and varied trapping timer [930].

Abbreviations: FID = flame ionization detector; GC = gas chromatography; MS = mass spectometry; CLMD = chemiluminescence detection; ECD = electron capture detector; GC = gas chromatography; HSD = halogen-specific detector; ITD = ion trap detector; MS = mass spectrometry NR = not reported [930].

Purge and trap methods are standard for the determination of carbon tetrachloride in water, with analyte measurement by gas chromatography using halogen-specific detection, electron-capture detection or mass-spectrometry [930]. The APHA methods for carbon tetrachloride have been accepted by EPA as equivalent to EPA-developed methods [930]. Analyte measurement using an ion trap detector that functions as a mass spectrometer has also been evaluated [930]. This method is sufficiently sensitive to measure the analytes below the regulatory levels [930]. Headspace sampling, coupled with whole column cryotrapping chromatography and mass spectrometry, have been used in the analysis of volatile priority pollutants in water and waste water [930]. The advantage of headspace sampling over other methods of analysis include minimal sample preparation, injection of a larger sample preparation and, and shorter analysis timer because all of the compounds being analyzed are volatile [930]. Carbon tetrachloride can also be determined in solid wastes by purge and trap collection followed by gas chromatography [930]. A modified open- loop dynamic headspace technique has been applied for stripping and trapping volatile organic compounds from estuarine sediments [930]. This method is capable of quantifying volatile organic compounds at detection limits between 10 and 100 ng/kg [930].

Related compounds: when this volatile compound is found in environmental samples, the investigator should also consider analyzing for breakdown products hexachloroethane and chloroform which may be present in the environment when this compound is present.

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.

Description of EPA standard methods 8240 and 8260 (8260 is replacing 8240 [1013]) from EPA EMMI Database [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].

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 (for GC/MS Volatile Organics):

Note: 8260 is replacing 8240 [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].

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].