ENVIRONMENTAL CONTAMINANTS ENCYCLOPEDIA

VINYL CHLORIDE ENTRY

July 1, 1997

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

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

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

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

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

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

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

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

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

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

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

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

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

on the internet or NTIS: 1998).

Vinyl Chloride (VC, CAS number 75-01-4)

Brief Introduction:

Br.Class: General Introduction and Classification Information:

Vinyl chloride is considered a volatile organic compound (VOC) [868,903]. This compound is considered a purgeable halocarbon [1010]. It is a toxic pollutant designated pursuant to section 307(a)(1) limitations (40 CFR 401.15, 7/1/90) [609].

Vinyl chloride is a colorless vapor with a mild, sweet odor. It can exist in liquid form if it is kept under high pressure. Almost all vinyl chloride is man-made. Most of the vinyl chloride produced in the United States is used to make polyvinyl chloride (PVC). PVC is used to make a variety of plastic products including pipes, wire and cable coatings, and packaging materials. Others include furniture and automobile upholstery, wall coverings, housewares, and automotive parts. At one time, vinyl chloride was also used as a coolant, a propellant in spray cans, and in some cosmetics. It is no longer used for these purposes [938].

Most of the vinyl chloride that enters the environment comes from plastics industries that release it into the air or into waste water. EPA limits the amount industries may release. Vinyl chloride also comes from tobacco smoke and is a breakdown product of other man-made chemicals in the environment. Vinyl chloride has entered the environment at hazardous waste sites as a result of improper disposal, leakage from storage containers, from spills, or from the breakdown of other chemicals [938].

Vinyl chloride is a carcinogenic priority pollutant [446]. Vinyl chloride is included as one of the 19 most regulated chemicals in the 1990 publication "List of lists of worldwide hazardous chemicals and pollutants" [621]. Its use in pesticides has been suspended [187].

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.

Vinyl chloride is thought to be potentially hazardous to fish and wildlife which encounter it in the environment. It has therefore been suggested as candidate for consideration for future inclusion in FWS (contract) laboratory analytical scans (Brian Cain, FWS, personal communication, 1992).

It appears that metabolism of vinyl chloride is necessary before many of its toxic effects occur (Clayton, G. D. and F. E. Clayton, eds., Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3538) [609].

Potential Hazards to Humans:

Vinyl chloride does not exert clearly perceptible acute effects below 1,000 ppm. At that dose humans exhibit slight anesthesia, drowsiness, slight visual disturbances, faltering gait, numbness, & tingling of extremities (Lefaux, R. Practical Toxicology of Plastics. Cleveland: CRC Press Inc., 1968. 82) [609].

If spilled on skin rapid evaporation can cause local frostbite (Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1572) [609].

Inhalation of vinyl chloride has been shown to produce lung congestion & some hemorrhaging, blood-clotting difficulties, & congestion of liver & kidneys in lab animals (National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 784) [609].

In acute vinyl chloride intoxication, patients complain of vertigo, nausea and headache. At higher concentrations, vinyl chloride exerts a narcotic effect. In patients with chronic occupational exposure, neurological disturbances include sensory-motor polyneuropathy, trigeminal sensory neuropathy, slight pyramidal signs and cerebellar and extrapyramidal motor disorders. Psychiatric disturbances present as neurasthenic or depressive syndromes. Sleep disorders and disorders of sexual functions are frequently encountered. Pathological EEG alterations can be found in a high proportion of patients. The long term course and prognosis of the neurological and psychiatrical disorders in vinyl chloride disease are obscure. In an own case, a slight sensory polyneuropathy, bilateral hyposmia, a marked neurasthenic syndrome, typical EEG changes and computed tomography signs of cerebral atrophy were found in a 56 years old patient as late as 16 years after the exposure to vinyl chloride (Podoll K et al; Fortschr Neurol Psychiatr 58 (11): 439-43 (1990) [609].

A comprehensive toxicological profile for vinyl chloride, especially as it relates to human health, is available from ATSDR [938]. Due to lack of time, important highlights from this ATSDR document have not yet been completely incorporated into this entry. Also, EPA has a health advisory on this compound, available through the Office of Drinking Water, EPA, Washington, D.C. or through NTIS.

However, since there is so much information available related to human health, much of the information summarized below is taken from various government summary sources such as the Hazardous Substances Data Bank [609], EPA IRIS database [893], and the ATSDR Human Toxicology Profile [938].

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

EPA 1996 [952]:

Classified by EPA as a confirmed human carcinogen (Class A). Vinyl chloride cancer slope factor: 1.9 mg/kg/day [952].

EPA 1996 IRIS database information [893]:

Carcinogenicity Assessment: Under Review 07/01/94. A risk assessment for this substance/agent is under review by an EPA work group.

This compound has been treated as a carcinogen for model calculation purposes in some EPA risk-based (RBC and PRG) models [868,903].

Mechanism of Action:

An epoxide is the critical genotoxic metabolite derived from vinyl chloride, and it has been easier to demonstrate the formation of reactive epoxides from vinyl chloride than from other solvents such as TCE [494]. The vinyl chloride metabolite epoxides and resulting oxiranes are highly reactive and therefore can covalently bind to nucleic acids with the eventual end result of mutations and cancer [494,609].

Precarcinogen vinyl chloride converted to alkylating intermediate responsible for introduction of 2-oxyethyl group onto nucleophilic sites in DNA & proteins of mice (Gothe et al; Biochem Biophys Res Commun 76, 2: 259, 1977) [609].

Older Summaries:

NIOSH has recommended that vinyl chloride be treated as a potential human carcinogen. (NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS Publication No. 90-117. Washington, DC: U.S. Government Printing Office, June 1990 224) [609].

Classification of carcinogenicity: 1) evidence in humans: sufficient; 2) evidence in animals: sufficient; Overall summary evaluation of carcinogenic risk to humans is group 1: The chemical is carcinogenic to humans. /From table/ (IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT., multivolume work, p. S7 373, 1987) [609].

Classified as A1 = Confirmed human carcinogen. (American Conference of Governmental Industrial Hygienists. Threshold Limit Values for Chemical Substances and Physical Agents and Biological ExposureIndices for 1992-1993. Cincinnati, OH: ACGIH, 1992. 37) [609].

Vinyl chloride is a confirmed human carcinogen producing liver and blood tumors [620]. An industrial chemical gas, vinyl chloride, has been implicated as the causative agent of sarcoma of blood vessels in the livers of exposed workers [277].

Drinking water concentrations even lower than a concentration commonly used as a detection limit (10 ug/L) may result in an unacceptable human cancer risk [209].

A review of the data obtained from various studies on carcinogenicity of vinyl chloride (VC) in rodents, particularly on the effect of dose, age, duration of exposure and potential reversibility of lesions, revealed that vinyl chloride induced carcinogenicity in rodents was dose and time related; no recovery occurred in mice even after only 1 month of VC exposures or in rats after 6 month exposures. In addition, younger animals (2 months old) were more susceptible to VC induced carcinogenicity than animals held for 6 or 12 months prior to exposure. Initial 6 or 12 month exposures were adequate to detect the carcinogenic potential of VC. The above information was used as a basis for discussion on design of carcinogenicity studies. Possibility of determining the carcinogenic potential of a compound in a shorter period than the traditional 2 year studies in rodents was discussed in consideration with appropriate doses, species, age and exposure duration. Although this approach may be applicable to a strong carcinogen, it was not considered practicable in case of weak or unknown carcinogens (Bhandari JC; Toxicol Pathol 11, 2: 181-7. 1983) [609].

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

Although a statistically significant increase in congenital abnormalities has been observed in members of some communities located near a vinyl chloride processing facility, reports have failed to establish a statistically significant association between developmental toxicity and either parental occupation or proximity to the facility. In contrast, a number of inhalation studies using pregnant animals have shown developmental toxicity consisting of resorptions, decreased litter size and fetal weight, delayed ossification, and dilated ureters [938]. Therefore, it would be prudent to consider the possibliltiy of developmental effects in environmentally exposed human populations as well [938].

An excess of central nervous system defects, deformities of the upper alimentary and genital tracts, and clubfoot were observed in stillborn and live children in three

Ohio cities in which vinyl chloride polymerization plants are located (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. V19 398, 1979) [609].

The incidence of birth defects in infants born to residents of Shawinigan, Canada in 1966-1979 were significantly higher than in three comparison communities. There has been a vinyl chloride polymerization plant in this town since 1943 from which ten cases of liver angiosarcoma have been identified (Theriault G et al; Teratol 27, 3: 359-70, 1983) [609].

Vinyl chloride was administered for 7 hr/day on days 6-18 of gestation in mice, rats, & rabbits. It was concluded that although maternal toxicity was observed, vinyl chloride alone did not cause significant embryonal or fetal toxicity & was not teratogenic in any of the species @ concentration(s) tested (National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 785) [609].

Continuous exposure of cfy rats to vinyl chloride (4000 mg/cu m in air) during pregnancy caused increases in fetal deaths & embryotoxic effects (Ungvary G et al; Toxicology 11 (1): 45, 1978) [609].

Studies in humans indicate that male reproductive function may be adversely affected by exposure to vinyl chloride. Decreased androgen levels have been found in workers occupationally exposed to vinyl chloride. Also, workers have complained of impotency and decreased libido, and a decrease in sexual function was reported. These findings are supported by evidence of testicular damage in rats exposed by inhalation [938].

Fewer studies have reported the effects if vinyl chloride on reproductive function in females. However, one study suggests that menstrual activity may be disturbed in female vinyl chloride workers. Also, increased incidence and severity of elevated blood pressure and edema during pregnancy (preeclampsia) have been observed. Studies designed to examine these effects in animals were not located. At present, it is unclear whether adverse reproductive effects could occur in persons exposed to low levels of vinyl chloride in the air or water near hazardous waste sites. However, it would be prudent to consider the possibility of reproductive effets in environmentally exposed populations [938].

Vinyl chloride causes human reproductive effects (changes in spermatogenesis) via inhalation [620].

Russian studies examined sexual function and hormone levels in men and sexual function and gynecological health in women occupationally exposed to vinyl chloride and in unexposed control groups. An exposure and duration related decline in sexual function was reported in exposed men and women. Ovarian dysfunction, benign uterine growths, and prolapsed genital organs were reported in 77% of exposed women (Makarov IA et al; Gig Tr Prof Zabol 3: 22-7, 1984) [609].

Vinyl chloride is mutagenic in S. typhimurium (bacteria) in the vapor phase, but not when it is dissolved in water [938].

The effects of vinyl chloride were examined in the mouse hepatocyte primary culture/DNA repair assay. Based on preliminary toxicity tests, vinyl chloride was tested at concentrations of 5, 10 and 15% and was found to be cytotoxic at the 15% concentration. Vinyl chloride was genotoxic at all concentrations tested (Naylor Dana Institute; DNA Repair Tests of 11 Chlorinated Hydrocarbon analogs., 1983, EPA Document No. 40-8324292, Fiche No. OTS0509403) [609].

The vinyl chloride monomer induces increased chromosome changes (Siou G et al; Cahiers de Notes Documentaires - S'ecurit'e et Hygi'ene du Travail 2nd quarter No 107, Note No 1379-107-82 p.269-76, 1982) [609].

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

Liquid vinyl chloride evaporates easily into the air. Vinyl chloride in water or soil evaporates rapidly if it is near the surface. Vinyl chloride in the air breaks down in a few days.

With a vapor density of 2.15, vinyl chloride vapor tends to disperse slowly and flow along the ground, collecting in low spots. Thus, children playing along the ground will have relatively greater inhalation exposure to vinyl chloride than adults walking upright in the same area [938].

A limited amount of vinyl chloride can dissolve in water. It can enter groundwater and stay there for many years. It is unlikely that vinyl chloride will build up in plants or animals [938].

Inhalation is the major route of exposure for nearby residents and workers. Exposure is also possible by ingestion of contaminated foods, drinking water and absorption through skin from cosmetics (USEPA; Ambient Water Quality Criteria for Vinyl Chloride. p.C-2 USEPA-440/5-80-078, 1980) [609].

It is important to note that vinyl chloride is often the final breakdown product of the progression from tetrachloroethylene to trichloroethylene to dichloroethylene to vinyl chloride (Mario Fernandez, Jr., USGS, personal communication), 1994. For details, see the Fate.Detail section below.

Environmental Fate/Exposure Summary [609]:

Although vinyl chloride is produced in large quantities, almost all of it is used captively for the production of polyvinyl chloride (PVC) and other polymers. Therefore, its major release to the environment will be as emissions and wastewater at these production and manufacturing facilities. If vinyl chloride is released to soil, it will be subject to rapid volatilization with reported half-lives of 0.2 and 0.5 days for evaporation from soil at 1 and 10 cm incorporation, respectively. Any vinyl chloride which does not evaporate will be expected to be highly to very highly mobile in soil and it may leach to the groundwater. It may be subject to biodegradation under anaerobic conditions such as exists in flooded soil and groundwater. If vinyl chloride is released to water, it will not be expected to hydrolyze, to bioconcentrate in aquatic organisms or to adsorb to sediments. It will be subject to rapid volatilization with an estimated half-life of 0.805 hr for evaporation from a river 1 m deep with a current of 3 m/sec and a wind velocity of 3 m/sec. In waters containing photosensitizers such as humic acid, photodegradation will occur fairly rapidly. Limited existing data indicate that vinyl chloride is resistant to biodegradation in aerobic systems and therefore, it may not be subject to biodegradation in aerobic soils and natural waters. It will not be expected to hydrolyze in soils or natural waters under normal environmental conditions. If vinyl chloride is released to the atmosphere, it can be expected to exist mainly in the vapor-phase in the ambient atmosphere and to degrade rapidly in air by gas-phase reaction with photochemically produced hydroxyl radicals with an estimated half-life of 1.5 days. Products of reaction in the atmosphere include chloroacetaldehyde, hydrogen chloride, chloroethylene epoxide, formaldehyde, formyl chloride, formic acid, and carbon monoxide. In the presence of nitrogen oxides, eg photochemical smog situations, the half-life would be reduced to approximately a few hours. Since vinyl chloride is primarily used in limited number of locations, it is unlikely that contamination will be widespread. Major human exposure will be from inhalation of occupational atmospheres and from ingestion of contaminated food and drinking water which has come into contact with polyvinyl chloride packaging material or pipe which has not been treated adequately to remove residual monomer.

Synonyms/Substance Identification:

CHLORETHENE [609]
CHLORETHYLENE [609]
CHLOROETHENE [609]
CHLOROETHYLENE [609]
CHLORURE DE VINYLE (FRENCH) [609]
CLORURO DI VINILE (ITALIAN) [609]
ETHYLENE MONOCHLORIDE [609]
ETHYLENE, CHLORO- [609]
MONOCHLOROETHENE [609]
MONOCHLOROETHYLENE [609]
VC [609]
VCM [609]
VINILE (CLORURO DI) (ITALIAN) [609]
VINYL C MONOMER [609]
VINYL CHLORIDE MONOMER [609]
VINYLCHLORID (GERMAN) [609]
VINYLE(CHLORURE DE) (FRENCH) [609]
WINYLU CHLOREK (POLISH) [609]
Ethene, chloro- [609]
Trovidur [609]
Monovinyl chloride (MVC) [609]

Molecular Formula:
C_2-H_3-Cl [609]

Associated Chemicals or Topics (Includes Transformation Products):

See also individual entries:

1,1-Dichloroethylene
Trichloroethylene
Tetrachloroethylene

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:

- Dichloroethane
- Trichloroethane

Other Associated Materials:

- Hydrogen chloride

Impurities [609]:

Commercial grade contains 1-2% impurities: water, non-volatile residues, acetaldehyde, hydrogen chloride, hydrogen peroxide, and methyl chloride. [International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 2256].

Specifications for a typical commercial product call for maxima in mg/kg by weight of the following impurities: unsaturated hydrocarbons - 10; acetaldehyde - 2; dichloro compounds - 16; water - 15 ; hydrogen chloride - 2; nonvolatiles - 200; iron - 0.4. Phenol at levels of 25-50 mg/kg by weight is used as a stabilizer to prevent polymerization. [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. V7 292 (1972)].

The impurities of vinyl chloride are as follows: acetic aldehyde 5 ppm, butane 8 ppm, 1,3-butadiene 10 ppm, chlorophene 10 ppm, diacetylene 4 ppm, vinyl acetylene 10 ppm, propine 3 ppm, methylchloride 100 ppm. [Hiatt HH et al; Origins of Human Cancer Book A: Incidence of Cancer in Humans Vol #4 p.120 (1977)].

Metabolism/Metabolites [609]:

Rats were subjected to an airborne concentration(s) of (14)C-vinyl chloride ranging from 200-1,200 ppm in a closed system, The rate of decrease of vinyl chloride levels in the chamber atmosphere /was measured/. ... Saturation of the vinyl chloride-metabolizing enzymes of the rat /was/ achieved at 250 ppm. [Bolt HM et al; Arch Toxicol 7: 179-88 (1977) as cited in USEPA, Office of Drinking Water; Criteria Document (Draft): Vinyl Chloride p.IV-7 (1983)].

Data indicate dose-dependent fate of vinyl chloride after inhalation or oral admin in rats. Primary mechanism of detoxification of vinyl chloride or its reactive metabolites involves conjugation with hepatic glutathione. Glutathione conjugates ... Subject to hydrolysis yielding cysteine conjugates ... [National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 783].

The principal center of the metabolic process is the liver, where the monomer undergoes a number of oxidative processes, being catalyzed partly by alcohol dehydrogenase, and partly by a catalase. [International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 2256].

Data suggest that the alcohol dehydrogenase pathway is the major route of metabolism below 50 ppm, while the microsomal oxidase pathway is the major route at higher concentrations. [Hefner RE et al; Ann NY Acad Sci 246: 135-48 (1975)].

The first step in biotransformation of vinyl chloride has been proposed to involve microsomal oxidation leading to epoxide formation across the double bond. It has been suggested that the resulting oxiranes are highly reactive and therefore can covalently bind to nucleic acids with the eventual end result of mutations and cancer. [Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 695].

After inhalation of (14)c vinyl chloride by rats ... Three urinary metabolites have been detected: n-acetyl-s-(2-hydroxyethyl)cysteine, thiodiglycolic acid, & an unidentified substance. [National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 783].

N-acetyl-s-(2-chloroethyl)cysteine or n-acetyl-s-(2-hydroxyethyl)cysteine may be isolated from rat body fluids depending on method of protective esterification used. [Green T, Hathway DE; Chem-biol Interact 17 (2): 137 (1977)].

A strong correlation was found between vinyl chloride (VC) concentration(s) at working places and the incr excretion of thiodiglycolic acid of 18 exposed workers. The value obtained were in the range of 0.14-7.00 Ppm. The excretion of thiodigylcolic acid, measured by gc-ms analysis, amounted to 0.3-4.0 Mg/l. [MUELLER G ET AL; INT ARCH OCCUP ENVIRON HEALTH 41 (3): 199 (1978)].

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

W.Low (Water Concentrations Considered Low):

No information found.

W.High (Water Concentrations Considered High):

No information found.

W.Typical (Water Concentrations Considered Typical):

Information from HSDB [609]:

DRINKING WATER: In the National Organic Monitoring Survey (1976-7) 2 samples out of 113 contained detectable levels (>0.1 ppb) and these averaged 0.14 ppb(1). Highest value found in USA drinking water is 10 ppb(5,7). 23% of 133 USA cities using finished surface water were pos, 0.1 to

9.8 ppb, 0.4 ppb median of pos samples(2). A finished groundwater survey in 25 USA cities resulted in 4.0% pos, 9.4 ppb mean(2,6). One contaminated drinking water well contained 50 ppb(3). Drinking water from PVC pipes contained 1.4 ppb in a recent installation, while a 9 yr old system had 0.03 to 0.06 ppb(4). [(1) Drury JS, Hammons AS; Investigations of Selected Environmental Pollutants 1,2-dichloroethane. p. 63 USEPA-560/2-78-006 (1979) (2) Coniglio WA et al; The Occurrence of Volatile Organics in Drinking Water. USEPA Exposure Assessment Project (1980) (3) Burmaster DE; Environ 24: 6-13, 33-6 (1982) (4) USEPA; Ambient Water Quality Criteria for Vinyl Chloride. USEPA-440/5-80-078 (1980) (5) Fishbein L; Sci Total Environ 11: 111-61 (1979) (6) Council Environmental Quality; Contamination on Groundwater by Toxic Organic Chemicals. Washington, DC p. 84 (1981) (7) Kraybill HF; NY Acad Sci Annals 298: 80-9 (1977)].

DRINKING WATER: USA: National Screening Program, 1977-1981, 142 water supplies, 4.9% pos, trace to 76 ppb(1); state sampling data, 1033 supplies sampled, 7.1% pos, trace to 380 ppb(1). [(1) Cotruvo JA et al; p. 511-30 in Organic Carcinogens in Drinking Water (1986)].

GROUNDWATER: 4 of 1060 wells in New Jersey were positive(4). Vinyl chloride (VC) was present in the 10 most polluted wells from 408 New Jersey samples; however, vinyl chloride was not quantified(5). 15.4% of 13 US cities sampled were pos - 2.2 to 9.4 ppb, 5.8 ppb median(1,2). In a 9-state survey, 7% of the wells tested were positive, with a maximum value of 380 ppb reported(3). After train derailment in Manitoba on Mar 10, 1980, in which large amounts of VC was spilled in the snow, 10 ppm max occurred in groundwater which decreased to below 0.02 ppm by 10 wk after the spill(6). [(1) Coniglio WA et al; The Occurrence of Volatile Organics in Drinking Water. USEPA Exposure Assessment Project (1980) (2) Council Environmental Quality; Contamination on Groundwater by Toxic Organic Chemicals. Washington, DC p. 84 (1981) (3) Dyksen JE, Herr AF III; J Amer Water Work Assoc 1982, 394-403 (1982) (4) Page GW; Environ Sci Technol 15: 1475-81 (1981) (5) Greenberg M et al; Environ Sci Technol 16: 14-9 (1982) (6) Charlton J et al; p. 245-67 in Hazard Assessment of Chemicals Vol 2; Saxena J ed (1983)].

GROUNDWATER: USA 1982 National Ground Water Supply Survey, 466 samples, 1 sample pos at 1.1 ppb (1 ppb quantification limit)(1). [(1) Cotruvo JA; Sci Total Environ 47: 7-26 (1985)].

SURFACE WATER: 9.8 ppb max value found in a 1981, 9 state survey(2,3). It was not detected in winter or summer samples from the Delaware River(4). Vinyl chloride has been detected in 21 out of 606 samples from New Jersey(5) and other USA samples(6). 7.6% of 105 USA cities were positive with pos samples ranging from 0.2 to 5.1 ppb, 3.25 ppb median(1). [(1) Coniglio WA et al; The Occurrence of Volatile Organics in Drinking Water. USEPA Exposure Assessment Project (1980) (2) Burmaster DE; Environ 24: 6-13, 33-6 (1982) (3) Dyksen JE, Herr AF III; J Amer Water Work Assoc 1982, 394-403 (1982) (4) Sheldon LS, Hites RA; Environ Sci Technol 12: 1188-94 (1978) (5) Page GW; Environ Sci Technol 15: 1475-81 (1981) (6) Fishbein L; Sci Total Environ 11: 111-61 (1979)].

On the basis of various model simulations ... it appears that vinyl chloride should not remain in the aquatic ecosystem under most natural conditions. The loss of vinyl chloride at constant temperature and pressure is a function of water turbulence and mixing efficiency. [Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume II. EPA-440/4-79-029b. Washington, D.C.: U.S.Environmental Protection Agency, December 1979.,p. 49-4].

Experimental decrease of 16 mg/l ... /is/ 96% in 2 hours when stirred rapidly at 22 deg C in an open beaker of distilled water. In contrast, quiescent water under the same conditions yielded a ... concentration(s) loss over 2 hours of only 25%. Assuming that all processes involved are strictly first order, the volatilization loss data above yields half-lives of 25.8 minutes for the stirred case and 290 minutes for the quiescent case. [Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume II. EPA-440/4-79-029b. Washington, D.C.: U.S.Environmental Protection Agency, December 1979.,p. 49-5].

Effluents Concentrations [609]:

The only industry with appreciable waste water effluents of vinyl chloride is the organic chemicals mfg/plastic industry where mean levels are 750 ppb(1). Waste water from 12 PVC plants in 7 USA areas ranged from 0.05 to 20 ppm with typical levels being 2 to 3 ppm(2). Vinyl chloride has been detected in effluents from chemical and latex plants in Long Beach, California(4). It was not detected in effluents from major municipal waste water discharges in Southern California(3). Groundwater from hazardous waste sites, CERCLA Database, 178 sites, 8.7% pos for vinyl chloride(5). [(1) USEPA; Treatability Manual. p.I.12.12-1 to I.12.12-4 (1981) USEPA-600/2-82-001a (1981) (2) USEPA; Ambient Water Quality Criteria for Vinyl Chloride. USEPA-440/5-80-078 (1980) (3) Young DR; Annual Rep Southern California Coastal Water Res Proj p.103-12 (1978) (4) Fishbein L; Sci Total Environ 11:

111-61 (1979) (5) Plumb RH Jr; Ground Water Monit Rev 7: 94-100 (1987)].

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):

National Ambient Water Quality Criteria for aquatic organisms in ug/L [446]:

Freshwater Acute Criteria: None Published [446]

Freshwater Chronic Criteria: None Published [446,689,893].

Marine Acute Criteria: None Published [446,689,893].

Marine Chronic Criteria: None Published [446,689,893].

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]:

CAS 75-01-4, VINYL CHLORIDE (ug/L)

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

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

SECONDARY ACUTE VALUE: 1570

SECONDARY CHRONIC VALUE: 87.8

ESTIMATED LOWEST CHRONIC VALUE - FISH: 28,879

LOWEST CHRONIC VALUE - DAPHNIDS: No information found.

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

LOWEST CHRONIC VALUE - AQUATIC PLANTS: No information found.

ESTIMATED LOWEST TEST EC20 - FISH: 14,520

LOWEST TEST EC20 - DAPHNIDS: No information found

SENSITIVE SPECIES TEST EC20: No information found.

POPULATION EC2O: No information found.

The Netherlands' Harmonized (between media) Maximum Permissible Concentration (MPC) for this compound in water is 820 ug/L [655].

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

The Netherlands' Harmonized (between media) Negligible Concentration (NC) for this compound in water is 1% of the MPC, or 8.2 ug/L [655].

Wisconsin has a sport fish water quality standard of 0.15 ug/L (ppb) related to human cancer concerns; non-water supply standards for fish are as low as 3.7 ug/L [938].

W.Plants (Water Concentrations vs. Plants):

No information found.

W.Invertebrates (Water Concentrations vs. Invertebrates):

IC50 is the concentration at which inhibition of a biological process occurs for 50% of the test population. IC50s for population growth in Tetrahymena pyriformis (a ciliate) range from 405 to 806 mg/L [998].

W.Fish (Water Concentrations vs. Fish):

Few data on the responses of freshwater and marine organisms to chloroethene ... reported complete mortality of northern pike (Esox lucius) after a 10 day exposure at 388 ppm chloroethene (Brown et al; Chemical Pollutants in Relation to Diseases in Fish 298: 535-46, 1977) [609]

Wisconsin has a sport fish water quality standard of 0.15 ug/L (ppb) related to human cancer concerns; non-water supply standards for fish are as low as 3.7 ug/L [938].

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 75-01-4 (Vinyl chloride), the benchmarks are [650]:

SPECIES	WATER CONCENTRATION (ppm)
Rat (test species)	0.00000
Short-tailed Shrew	2.18500
Little Brown Bat	3.77700
White-footed Mouse	1.41200
Meadow Vole	2.47100
Cottontail Rabbit	1.17100
Mink	1.21400
Red Fox	0.86700
Whitetail Deer	0.48500

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

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

EPA 1996:

MCL 2.0E-03 mg/L [952].

Cancer slope factor: 1.9 mg/kg/day [952].

EPA 1996 IRIS database information [893]:

No MCL, MCLG, RfD, critical dose, or drinking water criteria for human health given in IRIS.

EPA 1995 Region 9 preliminary remediation goal (PRG) for tap water [868]: 2.0E-02 (0.02) ug/L.

Nine states have water quality standards of 1 ug/L (ppb) or less for drinking water [938]. States having standards below 1 ppb include MN (0.15 ug/L), WI (0-.2 ppb), and RI (0 ppb) [938].

Drinking water concentrations even lower than a concentration commonly used as a detection limit (10 ug/L) may result in an unacceptable human cancer risk [209].

Older references:

National Ambient Water Quality Criteria for protection of human health in ug/L (Human Health (10-6 Risk Level for Carcinogens):

Published Criteria for Water and Organisms: 2.0 [446,689].

Published Criteria for Organisms Only: 525 [446,689]

IRIS Recalculated (9/93) Criteria for Water and Organisms: 2.0 ug/L [689]

IRIS Recalculated (9/90) Criteria for Organisms Only: 530 ug/L [689].

Criteria Federal Register Notice Number: 45 FR 79341 [446].

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] .

The national revised primary drinking water maximum contaminant level for vinyl chloride for community and non-transient, non-community water systems is 0.002 mg/l (40 CFR 141.61 (7/1/90), amended by 56 FR 3593, 1/30/91) [609]

For the maximum protection of human health from the potential carcinogenic effects due to exposure of vinyl chloride through ingestion of contaminated water and contaminated organisms, the ambient water concentration(s) should be zero, based on the nonthreshold assumption for this chemical. However, zero levels may not be attainable at the present time. Therefore, the levels which may result in incremental increases of cancer risk over a lifetime are estimated at 1X10-5, 1X10-6, or 1X10-7. The corresponding recommended criteria are 20 ug/l, 2.0 ug/l, and 0.2 ug/l, respectively. If these estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 5,246 ug/l, 525 ug/l, and 52.5 ug/l, respectively (USEPA; Quality Criteria for Water 1986: Vinyl chloride; May 1,1986; EPA 440/5-86-001) [609]

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

No information found.

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):

Analyses of sewage sludges from 50 publicly owned treatment works by the U.S. Environmental Protection Agency (1985): The mean concentration of vinyl chloride was 35.4 ppm (dry weight) [347].

Sed.Typical (Sediment Concentrations Considered Typical):

No information found.

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 Vinyl Chloride (CAS 75-01-4), the bencmark is:

ESTIMATED EQUIVALENT SEDIMENT QUALITY CRITERION at 1% Organic Carbon: 0.021

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

The Netherlands' Harmonized (between media) Maximum Permissible Concentration (MPC) for this compound in sediments is 1.4 mg/kg [655].

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

The Netherlands' Harmonized (between media) Negligible Concentration (NC) for this compound in sediments is 1% of the MPC, or 0.014 mg/kg [655].

Sed.Plants (Sediment Concentrations vs. Plants):

No information found.

Sed.Invertebrates (Sediment Concentrations vs. Invertebrates):

No information found.

Sed.Fish (Sediment Concentrations vs. Fish):

No information found.

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

No information found.

Sed.Human (Sediment Concentrations vs. Human):

No information found.

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

No information found.

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

Soil.Low (Soil Concentrations Considered Low):

No information found.

Soil.High (Soil Concentrations Considered High):

After March 10, 1980 train derailment in Canada in which large quantities of vinyl chloride were spilled in the snow, soil samples reached levels as high as 500 ppm between one and two meters below the soil surface (Charlton J et al; p.245-67 in Hazard Assessment of Chemicals Vol 2; Saxena J ed, 1983) [609]

Analyses of sewage sludges from 50 publicly owned treatment works by the U.S. Environmental Protection Agency (1985): The mean concentration of vinyl chloride was 35.4 ppm (dry weight) [347].

Soil.Typical (Soil Concentrations Considered Typical):

No information found.

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

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

The Netherlands' Harmonized (between media) Maximum Permissible Concentration (MPC) for this compound in soil is 1.4 mg/kg [655].

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

The Netherlands' Harmonized (between media) Negligible Concentration (NC) for this compound in soil is 1% of the MPC, or 0.014 mg/kg [655].

Soil.Plants (Soil Concentrations vs. Plants):

No information found.

Soil.Invertebrates (Soil Concentrations vs. Invertebrates):

No information found.

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

No information found.

Soil.Human (Soil Concentrations vs. Human):

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

SSL = 0.3 mg/kg for ingestion pathway [952].

SSL = 0.03 mg/kg for inhalation pathway [952].

SSL = 0.0007 to 0.01 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: 5.2E-03 mg/kg wet wt.
Industrial Soil: 1.1E-02 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:

0.01 mg/Kg dry weight [903].

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

No information found.

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

Tis.Plants:

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

No information found.

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

No information found.

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:

No information found.

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):

Legal Limits for Concentrations in Fish and Fishery Products: The only apparent legal limit is 0.01 mg/kg (Sweden) [216,418].

For risk to human adults eating fish, separate carcinogenic and non-carcinogenic risk-based fish tissue concentrations were calculated [903]. The following EPA Region III fish tissue risk-based concentration (RBC) benchmark utilizes the lower of the two concentrations (carcinogenic), rounded to two significant figures [903]:

RBC = 0.0017 mg/Kg wet weight.

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

No information found.

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

No information found.

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]:

Fin vinyl chloride (CAS 75-01-4), the benchmarks are:

SPECIES	NOAEL (mg/kg/day)	FOOD CONCENTRATION (ppm)
Rat (test species)	0.17000	0.00000
Short-tailed Shrew	0.48100	0.80100
Little Brown Bat	0.60400	1.81300
White-footed Mouse	0.42400	2.74100
Meadow Vole	0.33700	2.96600
Cottontail Rabbit	0.11300	0.57300
Mink	0.12000	0.87800
Red Fox	0.07300	0.73200

Whitetail Deer	0.03200	1.03100

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

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

No information found.

Tis.Human:

A) Typical Concentrations in Human Food Survey Items:

Food Survey Results [609]:

Concentrations of 20 mg/kg were detected in alcoholic beverages which were packaged in products containing vinyl chloride(1,3). Alcoholic beverages - 0.025 to 1.60 ppm. 0.44 ppm avg, edible oils - 0.3 to 3.29 ppm, 2.16 ppm avg, vinegars 0 (red wine) to 8.40 ppm (apple cider), detected but not quantified in butter and margarine when these products were packaged in PVC containers(2,3). [(1) IARC; Monograph Some Anti-Thyroid and Related Substances, Nitrofurans and Industrial Chemicals 7: 291-318 (1974) (2) USEPA; Ambient Water Quality Criteria for Vinyl Chloride. p 6-7 (1980) EPA-440/5-80-078 (3) Fishbein L; Sci Total Environ 11: 111-61 (1979)].

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 [952]:

MCL 2.0E-03 mg/L

Cancer slope factor: 1.9 mg/kg/day [952].

For risk to human adults eating fish, separate carcinogenic and non-carcinogenic risk-based fish tissue concentrations were calculated [903]. The following EPA Region III fish tissue risk-based concentration (RBC) benchmark utilizes the lower of the two concentrations (carcinogenic), rounded to two significant figures [903]:

RBC = 0.0017 mg/Kg wet weight.

Acceptable Daily Intake [609]:

The ten day health advisory for vinyl chloride for a 10 kg child that consumes one liter of water/day is 2.6 mg/day or 0.26 mg/kg/day. [USEPA/ODW; Vinyl Chloride Health Advisory (Draft) p.7 (1985)].

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

A strong correlation was found between vinyl chloride (VC) concentration(s) at working places and the incr excretion of thiodiglycolic acid of 18 exposed workers. The value obtained were in the range of 0.14-7.00 Ppm. The excretion of thiodigylcolic acid, measured by GC-MS analysis, amounted to 0.3-4.0 Mg/l (Mueller G et al; Int Arch Occup Environ Halth 41 (3): 199, 1978) [609].

Tis.Misc. (Other Tissue Information):

No information found.

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

BCF 1.17 l/kg [689].

Bioconcentration [609]:

Based on a reported water solubility of 2,700 mg/l(1), a BCF of 7 was estimated(3,SRC). Based on the estimated BCF, vinyl chloride will not be expected to significantly bioconcentrate in aquatic organism(SRC). While not reporting actual bioconcentration factors, a lack of appreciable bioconcentration in extractable fractions of fish and aquatic invertebrates was reported in an ecosystem study(2). [(1) Riddick JA et al; Organic Solvents: Physical Properties and Methods of Purification. Techniques of Chemistry. 4th ed. Wiley-Interscience pp. 1325 (1986) (2) Lu PY et al; Arch Enivron Contam Toxicol 9: 1042-8 (1977) (3) Lyman WJ et al; Handbook of Chem Property Estimation Methods Environ Behavior of Org Compounds McGraw-Hill NY p. 4-9 (1982)].

Some /data indicated/ that vinyl chloride is too readily volatilized to undergo bioaccumulation, except perhaps in the most extreme exposure conditions. Studies on five bacterial, three fungal, and two single organism cultures from natural aquatic systems did not show bioaccumulation to be an appreciable process. [Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume II. EPA-440/4-79-029b. Washington, D.C.: U.S.Environmental Protection Agency, December 1979.,p. 49-6].

Biological Half-Life [609]:

The pattern of pulmonary elimination of 10 and 1000 ppm vinyl chloride was described by apparently similar first-order kinetics, with half-lives of 20.4 And 22.4 Minutes respectively. The half lives for the initial phase of excretion of (14)c radioactivity in urine were 4.6 And 4.1 Hours, respectively. [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. V19 392 (1979)].

Interactions:

Information from HSDB [609]:

Sprague-dawley male rats received either 5% ethanol in drinking water or drinking water only for 4 wk prior to beginning inhalation of 600 ppm vinyl chloride for 4 hr/day on 5 days/wk for 12 mo. After 60 weeks from the first vinyl chloride exposure, liver tumors were found in 75% of the vinyl chloride-ethanol rats and in 38% of the vinyl chloride-only group. [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. V19 388 (1979)].

Vinyl chloride exerts a protective effect on hepatotoxicity when administered with vinylidene chloride. [Jaeger RJ; Ann NY Sci 246: 150-1 (1975) as cited in USEPA, Office of Drinking Water; Criteria Document (Draft): Vinyl Chloride p.VI-2 (1983)].

The metabolism of vinyl chloride was inhibited by administering a single dose of 320 mg/kg pyrazole one hr prior to inhalation of /vinyl chloride/ gas. [Hefner RE Jr et al; Ann NY Acad Sci 246: 135-48 (1975) as cited in USEPA; Ambient Water Quality Criteria Doc: Vinyl Chloride p.C-21 (1980) EPA 440/5-80-078].

Vinyl chloride and ethylene are acutely hepatotoxic in rats pretreated with polychlorinated biphenyl. ... Trichloropropane oxide significantly incr vinyl chloride toxicity in fasted but not in fed rats. Diethylmaleate significantly lowered hepatic glutathione during exposure, but did not increase hepatotoxicity of either vinyl chloride or ethylene. ... In polychlorinated biphenyl-treated rats, hepatic glutathione and hepatic epoxide hydrase influence the acute hepatotoxicity of vinyl chloride. [Conolly RB, Jaeger RJ; Toxicol Appl Pharmacol 50 (3): 523-32 (1979)].

/Combining/ 1 mg/cu m vinyl chloride with 1 mg phenol/cu m antagonized the effects on the nervous system of rats in a 7 mo continuous inhalation study. The mixture did not affect the learning ability which was impaired by 1 mg/cu m of either /cmpd/ separately. Vinyl chloride alone ... extended the blood clotting time. [Chyba A; Rocz Panstw Zakl Hig 32 (4): 357-61 (1981)].

Uses/Sources:

Major Uses [609]:

In plastic industry; as refrigerant; in organic syntheses. [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1572].

Monomer for poly(vinyl chloride) homopolymer [SRI].

Comonomer-eg, with vinyl acetate or vinylidene chloride. [SRI].

Chem intermed for methyl chloroform & 1,1,1-trichloroethane. [SRI].

Chem intermed for other org chems-eg, chloroacetaldehyde. [SRI].

Monomer & comonomer for fibers-eg, vinyon & saran fibers. [SRI].

Oxidn inhibitor in ethylene oxide prodn. [SRI].

Refrigerant & extraction solvent (former use) [SRI].

Vinyl chloride is used in the manufacture of numerous products in building and construction, automotive industry, electrical wire insulation and cables, piping, industrial and household equipment, medical supplies, and is depended upon heavily by the rubber, paper, and glass industries. [USEPA; Ambient Water Quality Criteria Doc: Vinyl Chloride p.A-1 (1980) EPA 440/5-80-078].

Adhesives for plastics [Sax, N.I. and R.J. Lewis, Sr., eds., Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 1223].

Vinyl chloride was formerly a component of aerosol propellants. Vinyl chloride and vinyl acetate copolymers are used extensively to produce vinyl asbestos floor tiles. [DHHS/NTP; Fourth Annual Report On Carcinogens p.200 (1985) NTP 85-002].

Limited quantities of chloroethene were used in the United States as an aerosol propellant and as an ingredient of drug and cosmetic products. (Former use) [USEPA; Health and Enviromental Effects Profile for Chloroethene; p.4 (1985) ECAO-CIN-P155].

Natural Sources [609]:

Vinyl chloride monomer is not known to occur in nature. [IARC; Monograph Some Monomers, Plastics and Synthetic Elastomers, and Acrolein 19: 377-83 (1979)].

Artificial Sources [609]:

Small quantities of chloroethene can be exposed to food by migration of chloroethene monomer present in polyvinyl chloride food wrapings and containers. [Gilbert SG et al; J Food Process Preserv 4 (1-2): 27-49 (1980) as cited in USEPA; Health and Enviromental Effects Profile for Chloroethene; p.14 (1985) ECAO-CIN-P155].

Sources of vinyl chloride include air emission from vinyl chloride production and use as a feedstock in the plastics industry (principally for PVC production) and wastewater from these industries(1). Vinyl chloride is also a product of anaerobic degradation of chlorination solvents such as would be expected to occur in groundwater and landfills(2). [(1) IARC; Monograph Some Monomers, Plastics and Synthetic Elastomers and Acrolein 19: 377-83 (1979) (2) Hallen et al; American Chem Soc 192 Annual Meeting, Anaheim CA 9/7-12/86 p. 344-346. (1986)].

Vinyl chloride monomer has been found in polyvinyl chloride resins but these levels can be reduced by new processing techniques in food grade resins(1). For example, PVC delivered to a fabricator contained 250 ppm vinyl chloride monomer which was reduced to 0.5-20 ppm after fabrication(1). Residual vinyl chloride monomer found in food packing material ranged from 0.043-71 ppb for film and up to 7.9 ppm for plastic bottles(1). It has been found in domestic and foreign cigarettes and little cigars in concentrations of 5.6-27 mg/cigarette(1). [(1) IARC; Monograph Some Monomers, Plastics and Synthetic Elastomers, and Acrolein 19: 381-3 (1979)].

Forms/Preparations/Formulations:

Information from HSDB [609]:

Grade: Technical, pure 99.9% [Sax, N.I. and R.J. Lewis, Sr., eds., Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 1223].

Vinyl chloride monomer is available commercially in cylinders or in bulk and is generally supplied as a liquid under pressure. [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. V7 292 (1974)].

Liquefied gas, polymer grade [Kuney, J.H. and J.N. Nullican (eds.) Chemcyclopedia. Washington, DC: American Chemical Society, 1988. 122].

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

Solubilities [609]:

Sol in alcohol, ether, carbon tetrachloride, benzene; slightly soluble in water. [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1572].

Soluble in hydrocarbons, oil, chlorinated solvents, and most common organic solvents. [Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. V23 865 (1985)].

Water solubility of 2700 mg/l [Riddick JA et al; Organic Solvents: Physical Properties and Methods of Purification. Techniques of Chemistry. 4th ed. Wiley-Interscience p. 1325 (1986)].

Vapor Pressure [609]:

2660 MM HG @ 25 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. V19 377 (1979)].

Octanol/Water Partition Coefficient [609]:

log Kow= 0.6 (calc) [Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume I. EPA-440/4 79-029a. Washington, DC: U.S.Environmental Protection Agency, December 1979.,p. 49-2].

Molecular Weight [609]:

62.50 [Lide, D.R. (ed). CRC Handbook of Chemistry and Physics. 72nd ed. Boca Raton, FL: CRC Press, 1991-1992.,p. 3-518].

Density/Specific Gravity [609]:

0.9106 @ 20 DEG C/4 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. V19 377 (1979)].

Henry's Law constant [609]:

0.0560 atm/cu m-mole [Hine J, Mookerjee PK; J Org Chem 40: 292-8 (1975)].

Surface Tension [609]:

23.1 dyn/cm at -20 deg C [Braker W, Mossman A; Matheson Gas Data Book 6th ED p.695 (1980)].

Vapor Density [609]:

2.15 (Air= 1) [Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 2728].

Viscosity [609]:

Viscosity, gas at 101.325 kPa at 20 deg C is 0.01072 cP; viscosity, liquid at -20 deg C is 0.280 cP [Braker W, Mossman A; Matheson Gas Data Book 6th ED p.695 (1980)].

Boiling Point [609]:

-13.37 deg C [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1572].

Melting Point [609]:

-153.8 deg C [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1572].

Color/Form [609]:

Colorless gas or liquid [Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 2728].

Odor [609]:

Ethereal odor [Sax, N.I. and R.J. Lewis, Sr., eds., Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand

Reinhold Co., 1987. 1223].

Sweet odor [Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, D.C.: Assoc. of American Railroads,Hazardous Materials Systems (BOE), 1987. 715].

Other Chemical/Physical Properties [609]:

Undergoes rapid photochemical oxidation. [Gay BW et al; Environ Sci Technol 10: 58-67 (1976)].

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

One potentially important aspect of the presence of vinyl chloride is that is can be the final breakdown product of tetrachloroethylene, trichloroethylene, and/or dichloroethylene. According to EPA's health advisories (available through the Office of Drinking Water, EPA, Washington, D.C. or through NTIS) on vinyl chloride and dichloroethylene, vinyl chloride is a degradation product of trichloroethylene and tetrachloroethylene in groundwater, with dichloroethylene being an intermediate breakdown product. The common progression is tetrachloroethylene to trichloroethylene to dichloroethylene to vinyl chloride (Mario Fernandez, Jr., USGS, personal communication, 1994).

Although some vinyl chloride can result from the breakdown of the above-listed solvents, not 100% of the breakdown route is to vinyl chloride (some other breakdown pathways exist and different resultant breakdown products are sometimes produced, Karl Ford, BLM, personal communication, 1994).

Information from HSDB [609]:

TERRESTRIAL FATE: If vinyl chloride is released to soil, it will be subject to rapid volatilization based on a reported vapor pressure of 2660 mm Hg at 25 deg C(1); half-lives of 0.2 and 0.5 days were reported for volatilization from soil incorporated into 1 and 10 cm of oil, respectively(2). Any vinyl chloride which does not evaporate will be expected to be highly mobile in soil. It may be subject to biodegradation under anaerobic conditions such as exists in flooded soil and groundwater; however, limited existing data indicate that vinyl chloride is resistant to biodegradation in aerobic systems and therefore, it may not be subject to biodegradation in natural waters. It will not be expected to hydrolyze in soils under normal environmental conditions(SRC). [(1) Riddick JA et al.; Organic Solvents: Physical Properties and Methods of Purification. Techniques of Chemistry. 4th ed. Wiley-Interscience p. 1325 (1986) (2) Jury WA et al; J Environ Qual 13: 573-9 (1984)].

AQUATIC FATE: If vinyl chloride is released to water, it will not be expected to hydrolyze, to bioconcentrate in aquatic organisms or to adsorb to sediments. It will be subject to rapid volatilization with an estimated half-life of 0.805 hr for evaporation from a river 1 m deep with a current of 3 m/sec and a wind velocity of 3 m/sec(1,SRC). In waters containing photosensitizers such as humic acid, photodegradation will occur fairly rapidly. Limited existing data indicate that vinyl chloride is resistant to biodegradation in aerobic systems and therefore, it may not be subject to biodegradation in natural waters(SRC). [(1) Lyman WJ et al; Handbook of Chemical Property Estimation Methods NY: McGraw-Hill p. 15-25 (1982)].

AQUATIC FATE: The rate of bulk exchange of gaseous vinyl chloride between atmosphere and water is about twice that of oxygen. As a result the loss of vinyl chloride by volatilization from water is probably the most significant process in its distribution. There is little information pertaining specifically to the rate of adsorption ... onto particulate matter. In a study on the behavior of vinyl chloride in water no significant difference in the rate of ... loss from distilled water, river water, or effluent from a vinyl chloride plant stirred at the same rate was found, thus indicating negligible adsorption ... onto particulate matter. ... Aquatic sediments could exhibit long-term storage of low levels ... if extreme environmental conditions, such as continual high levels of vinyl chloride input were present in water. [Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume II. EPA-440/4-79-029b. Washington, D.C.: U.S.Environmental Protection Agency, December 1979.,p. 49-6].

AQUATIC FATE: ... In environments such as municipal water chlorination facilities, high concentrations of chloride would exist. Under certain conditions, vinyl chloride may be converted to more highly chlorinated compounds based on the reactivity of carbon-carbon double bonds with chlorine and hypohalous acid. Dissolved vinyl chloride in water will readily escape into the gas phase, but chemical reactions can occur with water impurities which may inhibit its release. Many salts have the ability to form complexes with vinyl chloride and can increase its solubility. Therefore, the amounts of vinyl chloride in water could be influenced significantly by the presence of salts. [Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume II. EPA-440/4-79-029b. Washington, D.C.: U.S.Environmental Protection Agency, December 1979.,p. 49-7].

ATMOSPHERIC FATE: If vinyl chloride is released to the atmosphere, it can be expected to exist mainly in the vapor-phase in the ambient atmosphere(1,SRC) based on a reported vapor pressure of 2660 mm Hg at 25 deg C(2). Gas phase vinyl chloride is expected to degrade rapidly in air by reaction with photochemically produced hydroxyl radicals with an estimated half-life of 1.5 days(3,SRC). Products of reaction in the atmosphere include chloroacetaldehyde, HCl, chloroethylene epoxide, formaldehyde, formyl chloride, formic acid, and carbon monoxide(4). In the presence of nitrogen oxides, eg photochemical smog situations, the half-life would be reduced to a few hours(SRC). [(1) Eisenreich SJ et al; Environ Sci Technol 15: 30-8 (1981) (2) Riddick JA et al.; Organic Solvents: Physical Properties and Methods of Purification. Techniques of Chemistry. 4th ed. Wiley-Interscience pp.1325 (1986) (3) Perry RA et al; J Chem Phys 67: 458-62 (1977) (4) Muller JPH, Korte F; Chemosphere 6: 341-6 (1977)].

Biodegradation [609]:

Limited existing data indicate that vinyl chloride is resistant to biodegradation in aerobic systems(1,2). Vinyl chloride was approximately 50% and 100% degraded in 4 and 11 weeks, respectively, in the presence of sand by methanogenic microorganisms under anaerobic conditions in laboratory scale experiments(3). In the absence of sand 20% and 55% degradation occurred in 4 and 11 weeks, respectively(3). [(1) Helfgott TB et al; An Index of Refractory Organics, p. 21 USEPA-600/2-77-174 (1977) (2) Callahan MA et al; Water-related Environmental Fate of 129 Priority Pollutants Vol 2, p. 49-1 to 49-10 USEPA-440/4-79-029b (1979) (3) Brauch HJ et al; Vom Wasser 68: 23-32 (1987)].

Abiotic Degradation [609]:

The rate constant for the vapor phase reaction of vinyl chloride with photochemically produced hydroxyl radicals has been determined in laboratory experiments to be 6.60x10-12 cu cm/molecule-sec at 26 deg C(1) which corresponds to an atmospheric half-life of 1.5 days at an atmospheric concentration of 8X10+5 hydroxyl radicals per cu cm (SRC). Disappearance of approximately 50% of vinyl chloride exposed to sunlight outdoors in air occurred in 0.5 and 2 days in Sept and Dec, respectively(2). The products of reaction include chloroacetaldehyde, HCl, chloroethylene epoxide, formaldehyde, formyl chloride, formic acid and carbon monoxide(3,4). In the presence of nitrogen oxides, its reactivity is higher with a half-life of 3-7 hrs(2,5,6). In water no photodegradation was observed in 90 hours; however, degradation is rapid in the presence of sensitizers such as might be found in humic waters, or free radicals as might be found in PVC manufacturing effluent streams(7). Hydrolysis will not be a significant loss process(8). [(1) Perry RA et al; J Chem Phys 67: 458-62 (1977) (2) Carassiti V et al; Ann Chim 67: 499-512 (1978) (3) Muller JPH, Korte F; Chemosphere 6: 341-6 (1977) (4) Kagiya T et al; Japan Chem Soc Spring Term Mtg, 32nd Tokyo Japan Paper 1035 (1975) (5) Woldbaek T, Klaboe P; Spectrochim Acta A 34: 481-7 (1978) (6) Gay BW Jr et al; Environ Sci

Technol 10: 58-66 (1976) (7) Callahan MA et al; Water-related Environmental Fate of 129 Priority Pollutants Vol 2 p. 49-1 to 49-10 USEPA-440/4-79-029b (1979) (8) Mabey WR et al; Aquatic Fate Process Data for Organic Priority Pollutants p. 156 USEPA-440/4-81-014 (1981)].

Reacts at an extremely rapid rate with hydroxyl radicals, exhibiting a half-life on the order of a few hours with the subsequent formation of hydrogen chloride or formyl chloride as posible products. Formyl chloride, if formed, is reported to decompose thermally at ambient temperatures with a half-life of about 20 minutes, yielding carbon monoxide and hydrogen chloride. [Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume II. EPA-440/4-79-029b. Washington, D.C.: U.S.Environmental Protection Agency, December 1979.,p. 49-1].

Vinyl chloride, in the vapor phase, does not absorb light of wavelengths greater than 220 nm, and in water it does not absorb above 218 nm. As a result, direct photolysis ... would be expected, at best, to be a very slow process due to lack of overlap between vinyl chloride absorption and sunlight radiation spectra. ... It is, however, possible that light-induced transformations of vinyl chloride could occur through indirect photolysis. Photolysis experiments were conducted ... in natural water and in distilled water containing photosensitizers that absorb light of wavelengths greater than 300 nm. It was found that vinyl chloride in soln decomposed rapidly when irradiated with ultraviolet light in the presence of acetone, a high energy triplet sensitizer, or hydrogen peroxide, a free radical source. [Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume II. EPA-440/4-79-029b. Washington, D.C.: U.S.Environmental Protection Agency, December 1979.,p. 49-2].

Atmospheric photodissociation ... appears to be much less important than photochemical oxidation. Rapid photochemical oxidation is reported to remove the compound from the troposphere with a half-life of a few hours. As a result, neither the chlorine in vinyl chloride nor vinyl chloride itself is likely to diffuse to the stratosphere. Experiments ... indicate ... that if reactive radicals are present in natural waters at significant concn, they may degrade vinyl chloride. Experimental results show that vinyl chloride will not be significantly degraded by molecular oxygen at temperatures and oxygen concentration(s) present in natural waters. [Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume II. EPA-440/4-79-029b. Washington, D.C.: U.S.Environmental Protection Agency, December 1979.,p. 49-3].

Hydrolysis over a pH range of 4.3 to 9.4 does not appear to be an important pathway for loss of vinyl chloride from water.

The hydrolytic half-life ... has been estimated to be less than 10 years at 25 deg C. Since the volatilization rate ... is much more rapid than the predicted rate of hydrolysis, hydrolysis should not be a significant aquatic fate. [Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume II. EPA-440/4-79-029b. Washington, D.C.: U.S.Environmental Protection Agency, December 1979.,p. 49-4].

Soil Adsorption/Mobility [609]:

Based on a reported water solubility of 2,700 mg/L(1), a Koc of 56 was estimated(2,SRC). According to estimated Koc values, vinyl chloride will be expected to be highly mobile in soil(3,SRC). [(1) Riddick JA et al; Organic Solvents: Physical Properties and Methods of Purification. Techniques of Chemistry. 4th ed. Wiley-Interscience p. 1325 (1986) (2) Lyman WJ et al; Handbook of Chem Property Estimation Methods NY: McGraw-Hill p. 4-9 (1982) (3) Swann RL et al; Res Rev 85: 17-28 (1983)].

Volatilization from Water/Soil [609]:

Using a reported Henry's Law constant of 0.0560 atm/cu m-mole(4), a half-life of 0.805 hr was calculated for evaporation from a river 1 m deep with a current of 3 m/sec and with a wind velocity of 3 m/sec(1,SRC). Based on a high reported vapor pressure of 2,660 mm Hg at 25 deg C(3), volatilization from soil would be rapid(SRC); half-lives of 0.2 and 0.5 days were reported for volatilization from incorporation into soil at 1 and 10 cm of soil, respectively(2). [(1) Lyman WJ et al; Handbook of Chemical Property Estimation Methods NY: McGraw-Hill p. 15-25 (1982) (2) Jury WA et al; J Environ Qual 13: 573-9 (1984) (3) Riddick JA et al; Organic Solvents: Physical Properties and Methods of Purification. Techniques of Chemistry. 4th ed. Wiley-Interscience p. 1325 (1986) (4) Hine J, Mookerjee PK; J Org Chem 40: 292-8 (1975)].

Absorption, Distribution and Excretion [609]:

1. Following exposure of male rats by inhalation to 10 ppm (14)c vinyl chloride for 6 hours, urinary (14)c activity and expired vinyl chloride comprised 68 and 2%, respectively, of the recovered radioactivity; after exposure to 1000 ppm (14)c vinyl chloride, the proportion of radioactivity in the urine was lower and that expired as vinyl chloride higher, representing 56 and 12%, respectively ... . [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. V19 392 (1979)].

2. Male Sprague-Dawley rats were given single oral doses

(gavage) of (14)C vinyl chloride at 0.05, 1.0 or 100 mg/kg, ... routes and rates of elimination of (14)C activity were followed for 72 hr. ... Of the samples examined (liver, skin, plasma, muscle, lung, fat, and carcass), liver retained the greatest percentage of admin radioactivity at all doses. [Watanabe PG et al; Toxicol Appl Pharmacol 36: 339-52 (1976) as cited in USEPA; Office of Drinking Water; Criteria Document (Draft): Vinyl Chloride p.IX-3 (1983)].

3. Experiments with volunteers showed that 42% of an inhaled dose of vinyl chloride ... was retained in the lung. This value was independent of the concentration(s) of vinyl chloride in the air. Elim of vinyl chloride through the lung was negligible since its concentration(s) in expired air decreased immediately after cessation of exposure. [Krajewski J et al; Br J Ind Med 37 (4): 373-4 (1980)].

4. Oral doses of 0.05-1.0 Mg/kg in rats ... Pulmonary excretion was monophasic @ these doses, & urinary metabolites ... /Were n-acetyl-s-(2-hydroxyethyl)cysteine & thiodiglycolic acid/. At ... 100 Mg/kg, pulmonary excretion ... Biphasic & a greater percentage ... Expired as vinyl chloride--67%, compared with 1 or 2% @ lower dose. [National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 783].

5. The metabolic elimination of vinyl chloride in Rhesus monkeys /following inhalation exposure/ is a dose-dependent, saturable process. ... Below 200-300 ppm elimination is first-order. [Buchter A et al; Tox Lett 6: 33-6 (1980) as cited in USEPA, Office of Drinking Water; Criteria Document (Draft): Vinyl Chloride p.IV-8 (1983)].

6. It is easily absorbed by the human organism through the respiratory system from where it passes into the blood circuit and from there to the various organs and tissues. It is also absorbed through the digestive system as a contaminant of food and beverages, and through the skin. [International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 2256].

7. Gastrointestinal absorption of vinyl chloride in rats occurs rapidly following ingestion of aqueous or vegetable oil treatment solutions. ... Quantitatively, absorption of 98.7% from the gut occurred at an oral dose of 450 mg/kg. [Withey JR; J Toxicol Environ Health 1 (3): 381-94 (1976)].

Laboratory and/or Field Analyses:

In the past, many methods have been used to analyze for vinyl chloride [861,938,1010,1011,1013]. 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. In the past, EPA has also published separate (other than SW-846) guidance documents with suggestions on field sampling and data quality assurance related to sampling of sediments [1016] and soils [1017,1018,1019]. 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 private lab staff members).

EPA (CERCLA) publishes various Contract Laboratory Program (CLP) methods documents periodically, available from EPA and NTIS. CLP methods typically have higher detection limits and are thus more appropriate for use at very polluted superfund sites than for risk assessment or baseline work elsewhere. A few examples of past CLP documents (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.

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] or USGS method 9090, GC/PID (photoionization detector), or various GC/ECD (electron capture detector) methods should be used. The investigator should also specify the addition of any relevant compounds suspected of being present but not typically found on the standard EPA scans. Vinyl chloride can break down into reactive and hazardous epoxides and other oxidizing agents inside of living things [494]. Reaction products in air can include formaldehyde, and choroethylene epoxide [938]. In water or sediments, most vinyl chloride tends to evaporate into the air [938]. Like other VOCs, the persistence can be greater in groundwater.

However, since vinyl chloride itself is often the final breakdown product of the progression from tetrachloroethylene to trichloroethylene to dichloroethylene (see Fate.Detail section above), these other solvents should often be analyzed wherever vinyl chloride is found.

Recommended Detection Limits: In all cases, detection limits should be lower than comparison benchmarks or standards for various media of concern. Ideally, the detection limit should be at least 10 times higher than the comparison benchmark or criteria [676]. In concert with need to compare values with low benchmark concentrations, the regulatory requirements of States [938], and the capabilities of better labs, detection limits should be as low as possible to avoid false negatives.

Water Detection Limits: Some comparison benchmarks for VC are quite low: For example, the EPA 1995 Region 9 preliminary remediation goal (PRG) for tap water [868]: 2.0E-02 (0.02) ug/L. Sub ppb detection limits require the use halogen specific detectors [938]. Wisconsin requires a detection limit of 0.5 ug/L for all VOCs [923], but since some benchmarks are lower, the lower the better. USGS can achieve superior (lower) detection limits of 0.10 ug/L this compound using advanced methods such as USGS 1996 Custom Method 9090. GC/PID methods for drinking water can go as low as 0.02 ppb [938], the recommended default detection limit when drinking water is an issue. For scenarios not requiring low detection limits (for example, for NPDES permit applications using EPA method 601 for purgeable halocarbons) EPA specifies a water detection limit of 0.18 ug/L for this compound (40 CFR, Part 136, Appendix A, Table 1) [1010].

Solids Detection Limits: Some soil benchmarks require very low detection levels too: for example, the EPA SSL benchmark for soil can be as low as 0.0007 mg/kg (0.7 ppb) for protection from migration to groundwater, depending on the Dilution-Attenuation Factor (DAF) [952]. GC/HSD methods are required to get to below 1 ppb detection limits in soil [938]. Otherwise, the standard detection limits for soil, sediments, and tissues should be 2 ppb. The 2 ppb detection limit can be achieved using standard GC/ECD methods [938].

Field Protocols:

Standard field collection method protocols are published or internally distributed by the Fish and Wildlife Service, DOE, USGS, NOAA, and EPA. These recommendations change over time, with the newest recommendations sometimes being quite different than the old, thereby producing different results. The Fish and Wildlife Service methods are similar in many ways to NOAA field protocols [676]. Many recommended EPA field methods for organics are not very detailed, although the 3rd update of SW-846 for RCRA solid waste methods 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]. Mixing composite samples of volatile samples is not advisable since some of the compounds can thereby be lost through volatization to the air during the mixing process (Roy Irwin, National Park Service, Personal Communication, 1997). In some 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].

EPA and other agency method typically require the proper cleaning of collecting gear for both volatile and semi-volatile organics [1010,1013]. 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).

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].

Containers: Both EPA and APHA (Standards Methods Book) recommend glass containers for the collection of organic compounds [141,1010]. 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]. Actually, vials are not the best choice for avoiding false negatives through volatilization losses in soil samples, 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 EPA's SW-846 RCRA guidance authorizes the storage of soil samples of volatiles in EnCore TM (or equivalent, no government endorsement implied) samplers as long the sample is analyzed within 48 hours after collection [1013]. Several states also authorize the use of EnCore TM or equivalent containers (Donalea Dinsmore, State of Wisconsin DNR, personal communication, 1997).

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

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

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

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

For drinking water, in the past, EPA has recommended the following less rigorous methods for analyses of certain volatiles: Purge and trap capillary gas chromatography (EPA 502.2); gas chromatographic/mass spectrometry (EPA 524.2); purge and trap gas chromatography (EPA 503.1); gas chromatography/mass spectrometry (EPA 524.1); PQL= 0.005 mg/L [893].

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

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

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

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

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

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

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

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

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

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

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

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

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

> At minimum, before using contaminants data from diverse sources, one should determine that field collection methods, detection limits, and lab quality control techniques were acceptable and comparable. The goal is that the analysis in the concentration range of the comparison benchmark concentration should be very precise and accurate. Typical lab quality control techniques should have included the following considerations (John Moore, Fish and Wildlife Service, Personal Communication, 1997):
>
> Procedural Blanks should be analyzed to assure that no contaminants are added during the processing of the samples. The standards for adequacy depend on the method and the media being measured.
>
> > Different federal agencies publish different acceptable limits. For one program, NOAA stated that at least 8% of samples should be blanks, reference or control materials [676].
> >
> > The basic idea is that neither samples nor blanks should be contaminated. Because the only way to measure the performance of the modified procedures is through the collection and analysis of uncontaminated blank samples in accordance with this guidance and the referenced methods, it is highly recommended that any modifications be thoroughly evaluated and demonstrated to be effective before field samples are collected [1003].
>
> Duplicate samples are analyzed to provide a measure of

precision of the methods. The standards for adequacy depend on the method and the media being measured.

> Different federal agencies publish different acceptable limits. There appears to be an inverse relationship between precision and sensitivity [676].
>
> Some EPA methods state that a field duplicate must be collected at each sampling site, or one field duplicate per every ten samples, whichever is more frequent [1003]. Some protocols call for the preparation of one Ongoing precision and recovery (OPR) standard for every ten or fewer field samples. Great care should be taken in preparing ongoing precision and recovery standards [1003].

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

> Different federal agencies publish different acceptable limits.

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 from EPA EMMI Database on Lab methods [861]:

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

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]. Being replaced with 8260 in 3rd update of SW-846.

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]. Being replaced with 8260 in 3rd update of SW-846.

EPA Method 8260 (for GC/MS Volatile Organics):

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

EPA description [861]:

OSW 8260 Volatile Organics - CGCMS 58 SW-846 CGCMS ug/L MDL Method 8260 "Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique" The volatile compounds are introduced into the gas chromatograph by the purge and trap method or by direct injection (in limited applications) [861]. Purged sample components are trapped in a tube containing suitable sorbent materials [861]. When purging is complete, the sorbent tube is heated and backflushed with helium to desorb trapped sample components [861]. The analytes are desorbed directly to a large bore capillary or cryofocussed on a capillary precolumn before being flash evaporated to a narrow bore capillary for analysis [861]. The column is temperature programmed to separate the analytes which are then detected with a mass spectrometer interfaced to the gas chromatograph [861]. Wide capillary columns require a jet separator, whereas narrow bore capillary columns can be directly interfaced to the ion source [861]. If the above sample introduction techniques are not applicable, a portion of the sample is dispersed in solvent to dissolve the volatile organic constituents [861]. A portion of the solution is combined with organic- free reagent water in the purge chamber [861]. It is then analyzed by purge and trap GC/MS following the normal water method [861]. Qualitative identifications are confirmed by analyzing standards under the same conditions used for samples and comparing resultant mass spectra and GC retention times [861]. Each identified component is quantified by relating the MS response for an appropriate selected ion produced by that compound to the MS response for another ion produced by an internal standard [861]. Replacing 8240 in 3rd update of SW-846 [1013].

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].