7. ANALYTICAL METHODS

The purpose of this chapter is to describe the analytical methods that are available for detecting, measuring, and/or monitoring tetrachloroethylene, its metabolites, and other biomarkers of exposure and effect to tetrachloroethylene. The intent is not to provide an exhaustive list of analytical methods. Rather, the intention is to identify well-established methods that are used as the standard methods of analysis. Many of the analytical methods used for environmental samples are the methods approved by federal agencies and organizations such as EPA and the National Institute for Occupational Safety and Health (NIOSH). Other methods presented in this chapter are those that are approved by groups such as the Association of Official Analytical Chemists (AOAC) and the American Public Health Association (APHA). Additionally, analytical methods are included that modify previously used methods to obtain lower detection limits and/or to improve accuracy and precision.

7.1 BIOLOGICAL MATERIALS

Several methods are available for the analysis of tetrachloroethylene in biological media. The method of choice depends on the nature of the sample matrix; required precision, accuracy, and detection limit; cost of analysis; and turnaround time of the method. Since tetrachloroethylene is metabolized in the human body to trichloroacetic acid, trichloroacetic acid may be quantified in blood and urine as an indirect measure of tetrachloroethylene exposure (Monster et al. 1983). It should be pointed out that the determination of trichloroacetic acid may not provide unambiguous proof of tetrachloroethylene exposure since it is also a metabolite of trichloroethylene.

The main method used to analyze for the presence of tetrachloroethylene and trichloroacetic acid in biological samples is separation by gas chromatography (GC) combined with detection by mass spectrometry (MS) or an electron capture detector (ECD). Tetrachloroethylene and/or its metabolites have been detected in exhaled air, blood, urine, breast milk, and tissues. Preconcentration techniques are frequently used in tetrachloroethylene analysis. Preconcentration not only increases the sensitivity, but in certain instances, may also decrease the sample separation time. Interference in tetrachloroethylene analysis results from the widespread distribution of VOCs in the environment. The most likely sources of these interfering compounds are contamination from the vessels used to hold and prepare samples, contamination of the plumbing in the analytical instrument, and leaking of environmental contaminants into the sample vessel. Details on sample preparation, analytical method, and sensitivity and accuracy of selected methods are shown in Table 7-1.

Breath samples have been analyzed for tetrachloroethylene in several studies. Preconcentration on a solid sorbent followed by thermal desorption onto a cryogenic trap connected to the gas chromatograph was used to analyze exhaled air in several TEAM studies (Wallace 1986; Wallace et al. 1986a, 1986b, 1986c, 1986d). Vapors were thermally released directly onto the chromatographic column for separation and detection by electron impact MS (EIMS).

The methods most frequently used to determine the presence of tetrachloroethylene in biological tissues and fluids are headspace analysis and purge-and-trap, followed by GC/MS or GC/ECD. In headspace analysis, the gaseous layer above the sample is injected into the gas chromatograph. Samples may be hydrolyzed prior to analysis of headspace gases (Ramsey and Flanagan 1982). Headspace gases can be preconcentrated prior to GC analysis (Cramer et al. 1988; Michael et al. 1980) or injected directly into the gas chromatograph (Ramsey and Flanagan 1982). Sensitivity is in the low-ppb range, with generally good precision and accuracy for blood, serum, plasma, and urine (Cramer et al. 1988; Michael et al. 1980). The purge-and-trap method is used with liquid samples and involves purging the sample with an inert gas and trapping the purged volatiles on a solid sorbent. Blood and breast milk have been analyzed for tetrachloroethylene by purging onto a solid sorbent to concentrate the volatiles, followed by thermal desorption and analysis by GC/MS (Antoine et al. 1986; Pellizzari et al. 1982). However, the breast milk analysis was only qualitative, and recoveries appeared to be low for those chemicals analyzed (Pellizzari et al. 1982). Precision and sensitivity were comparable to headspace analysis, but accuracy was lower. Recovery of tetrachloroethylene from rat tissues was found to be greater when the tissues were homogenized in saline:isooctane (1:4) rather than saline alone (Chen et al. 1993).

Analysis of blood and urine for trichloroacetic acid has been done primarily by GC/ECD (Ziglio et al. 1984). Trichloroacetic acid has also been determined colorimetrically by decarboxylation to chloroform and conjugation with pyridine (Pekari and Aitio 1985a). The recovery and precision for this method were good, but the sensitivity was about a tenth that of GC/ECD methods (Christensen et al. 1988; Pekari and Aitio 1985a).

Static headspace capillary GC with serial triple detection is also a sensitive and reliable method for the determination of tetrachloroethylene in blood. Tetrachloroethylene is able to be separated out easily due to its volatility by headspace techniques. The detection limits for the photoionization detector (PID) and flame ionization detector (FID) were 68 ng/L and 35 ng/L, respectively (Schroers et al. 1998).

Table 7-1. Analytical Methods for Determining Tetrachloroethylene in Biological Materials

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Exhaled air	Collected in spirometer; pre-concentrated on Tenax-GC; thermally desorbed	HRGC/MS	4.10 µg/m^3 (605 ppt; (median quantifiable limit)	108–109	Wallace et al. 1986c
Blood	Purge and trap using 10 mL of blood	HRGC/MS	0.016 µg/L	97–131	Ashley et al. 1992
Blood	Thermally decarboxylated; subjected to static head-space analysis	GC/ECD (for metabolite TCA)	2 µg/L	101–109	Ziglio et al. 1984
Blood	Blood transferred to a pre-weighed SPME headspace vial using a 2-mL pre-cleaned glass syringe, agitated, and then transferred to the GC injection port	SPME-GC–MS/MS	0.020 µg/L	111–130	Aranda-Rodriguez et al. 2015
Blood	Antifoam agent added; purged and trapped on Tenax-GC/silica gel; thermally desorbed	GC/MS	Not reported	Not reported	Antoine et al. 1986
Blood	Sealed in gas-tight vial; heated, subjected to static head-space analysis	GC/PID, ECD, and FID	0.068 µg/L (GC/PID), and 0.035 µg/L (FID)	Not reported	Schroers et al. 1998
Blood	Stored in vacutainers at 4°C in the dark, transferred to SPME vial, and subjected to SPME headspace analysis	GC-MS	0.048–22 µg/L	Not reported	Blount et al. 2006
Blood, plasma, and serum	Sample in sealed vial subjected to static head-space analysis	GC/ECD	10 µg/L	Not reported	Ramsey and Flanagan 1982
Blood, urine, and adipose tissue	Passed inert gas over head-space of sample and trapped on Tenax-GC; thermally desorbed	HRGC/MS	Not reported	100 (blood); 72 (urine); 52 (adipose tissue)	Michael et al. 1980
Urine	Thermally decarboxylated; reacted with pyridine	UV-VIS spectro-photometry (for metabolite TCA)	≤0.5 µmol/L (≤80 µg/L)	93.5	Pekari and Aitio 1985a

Table 7-1. Analytical Methods for Determining Tetrachloroethylene in Biological Materials

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Urine	Enzyme hydrolysis of sample; decarboxylation of trichloroacetic acid; head-space gas analyzed	GC/ECD (for metabolite TCA)	20 µg/L	98	Christensen et al. 1988
Urine	Hydrolyzed with H_2SO_4; extracted with isooctane	GC/ECD (for metabolite trichloro-ethanol)	0.5 µmol/L (70 µg/L)	98.2	Pekari and Aitio 1985b
Urine	Stored in vacutainers, subjected to SPME headspace analysis	GC-MS	0.005 µg/L	Not reported	Poli et al. 2005
Tissue	Mixed with a proteolytic enzyme; incubated at 65°C; head-space gas analyzed	GC/ECD	Not reported	100	Ramsey and Flanagan 1982
Tissue	Homogenization in saline; extraction into isooctane; or direct homogenization into saline:isooctane; head-space gas analyzed	GC	1 ng	Saline homogenization, 69–105; isooctane homogenization, 81–99	Chen et al. 1993
Human milk	Purged warm; trapped in Tenax-GC; thermally desorbed	HRGC/MS	Qualitative identification	Not reported	Pellizzari et al. 1982

ECD = electron capture detector; FID = flame ionization detector; GC = gas chromatography; HRGC = high resolution gas chromatography; H_2SO_4 = sulfuric acid; MS = mass spectrometry; PID = photoionization detector; SPME = solid-phase microextraction; TCA = trichloroacetic acid; UV-VIS = ultraviolet-visible

7.2 ENVIRONMENTAL SAMPLES

Analysis of environmental samples is similar to that of biological samples. The most common methods of analyses are GC coupled to MS, ECD, a Hall's electrolytic conductivity detector (HECD), or a FID. Preconcentration of samples is usually done by sorption on a solid sorbent for air and by the purge-and-trap method for liquid and solid matrices. Alternatively, headspace above liquid and solid samples may be analyzed without preconcentration. Details of commonly used analytical methods for several types of environmental samples are presented in Table 7-2.

The primary methods of analyzing for tetrachloroethylene in air are GC combined with either MS or ECD. Air samples are collected on a solid sorbent, thermally desorbed to an on-column cryogenic trap and heat-released from the trapping column directly to the gas chromatograph (Bayer and Black 1987; EPA 1999a, 1999b; Krost et al. 1982; Wallace 1986; Wallace et al. 1986a, 1986b, 1986c, 1986d). Grab-samples of air can also be obtained and preconcentrated on a cryogenic column (Makide et al. 1979; Rasmussen et al. 1977). EPA Method TO-15 (EPA 1999a) and Method TO-17 (EPA 1999b) are identical, except that Method TO-17 uses an alternative sampling technique (direct sampling to solid sorbent tubes) rather than the collection in specially prepared stainless steel canisters followed by concentration using a solid sorbent and then thermal desorption. The limit of detection for cryogenic trapping followed by GC/ECD or GC/MS is in the low-ppt range (Krost et al. 1982; Makide et al. 1979; Rasmussen et al. 1977; Wallace et al. 1986a, 1986d). With careful technique, precision for both GC/ECD and GC/MS is acceptable, although the relative standard deviation (RSD) can be as high as ±28% (Krost et al. 1982; Rasmussen et al. 1977; Wallace et al. 1986a, 1986b, 1986c, 1986d).

The screening method for the detection of tetrachloroethylene in air also was performed using diffusive passive samplers and dual column capillary GC with tandem ECD/FID. Detection limits were 0.01 µg/m^3 with recovery of (±2 standard deviation) (Begerow et al. 1996).

An alternate method of analysis chemically desorbs tetrachloroethylene from activated coconut charcoal and directly injects the extract into a GC equipped with FID detection (NIOSH 1994; Peers 1985). The sensitivity of this method is only in the low-ppm range.

Table 7-2. Analytical Methods for Determining Tetrachloroethylene in Environmental Samples

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Air	Absorbed on coconut charcoal; desorbed with carbon disulfide	GC/FID (NIOSH Method 1003)	0.01 mg/sample	96	NIOSH 1994
Air	Air is collected in specially-prepared stainless steel canisters, or collected directly to a solid sorbent tube followed by thermal desorption	GC/MS (EPA Method TO-15, TO-17)	750 ppt	90–110	EPA 1999a, 1999b
Air	Collected in stainless steel canister; preconcentrated in cooled adsorbent; thermally desorbed	GC/ECD	1 ppt	Not reported	Makide et al. 1979
Air	Adsorbed on Tenax-GC thermally desorbed to on-column cold trap; heat-released	HRGC/MS	0.3 ppt	Not reported	Krost et al. 1982
Air	Collected in stainless steel canister; preconcentrated by cryogenic trapping; thermally desorbed	GC/ECD	0.2 ppt	Not reported	Rasmussen et al. 1977
Air	Adsorbed on Tenax-GC; thermally desorbed to on-column cold trap; heat-released	HRGC/MS	150–180 ppt (median quantifiable limit outdoor air)	108–109	Wallace et al. 1986c
Water	Purged and trapped in methyl silicone, ^{216}-diphenylene oxide polymer silica gel; thermally desorbed	GC/PI (EPA 503.1)	0.01–0.05 µg/L	97	APHA 1992
Water	Purged and trapped on coconut charcoal/ Tenax/silica gel; thermally desorbed	GC/MS (EPA Method 624)	4.1 µg/L	101	EPA 1982a
Water	Purged and trapped on coconut charcoal/ Tenax/silica gel; thermally desorbed	GC/HSD (EPA Method 601)	0.03 µg/L	94.1	EPA 1982a

Table 7-2. Analytical Methods for Determining Tetrachloroethylene in Environmental Samples

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Water	Equilibrated in sealed vial at room temperature; head-space gas injection	GC/ECD	Not reported	105	Dietz and Singley 1979
Water	Purged and trapped on Tenax-GC; thermally desorbed	GC/HECD; GC/FID	<0.1 µg/L (HECD); 1 µg/L (FID)	82 (HECD); Not determined (FID)	Otson and Williams 1982
Water	Purged and trapped on Tenax-GC; thermally desorbed	GC/HECD	Not reported	50–90	Wallace et al. 1986a, 1986d
Water	Sample directly injected	GC/UV	2 µg/L	68	Motwani et al. 1986
Water	*In situ* method; concentration in LDPE coating	FEWS/FT-IR	1 ppm (1,000 µg/L)	Not reported	Krska et al. 1993
Water	Spray extraction; trapped in sorption tube; thermally desorbed	GC/MS	0.010–0.030 µg/L	Not reported	Baykut and Voigt 1992
Landfill leachate	Extract with pentane; analyze	GC/MS	Not reported	Not reported	Schultz and Kjeldsen 1986
Liquid and solid waste	Equilibrated in sealed via headspace gas injected	GC/HSD (EPA Method 8010)	0.03 µg/L	94.1	EPA 1982b
Building materials and consumer products[a]	Collected by adsorption onto sorbent; thermally desorbed	HRGC/MS	Not reported	Not reported	Wallace et al. 1987
Soil	Collected in headspace vials, spiked with EPA-certified standard solvents, analysis by SPME	GC/MS	2 ng/g	Not reported	James and Stack 1996
Sediment	Spiked samples transferred to headspace analyzer	GC/MS (SIM mode)	0.2 ng/g	50.4–53.5	Kawata et al. 1997
Food	Undigested or H_2SO_4-digested samples at 90°C subjected to static head-space analysis	HRGC/ ECD; GC/MS	10–50 ng/g	92.5–98.6	Entz and Hollifield 1982

Table 7-2. Analytical Methods for Determining Tetrachloroethylene in Environmental Samples

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Food	Extraction with isooctane; clean-up on Florisil column if needed	GC/ECD; GC/HECD	3 ng/g (ECD); 10 ng/g (HECD)	>50	Daft 1988
Olive oil	Add Dekalin to vial with olive oil; seal vial; incubate at 70°C for 60 minutes; inject sample of head-space gas	GC/ECD	20 ng/g	Not reported	Pocklington 1992
Grains, grain-based foods	Purged and trapped on Tenax/XAD-4 resin; desorb with hexane	GC/ECD	Low- to sub-ppb	86–100	Heikes and Hopper 1986

[a]Sample is air from an environmental chamber containing the building material or consumer product.

ECD = electron capture detector; EPA = Environmental Protection Agency; FEWS = fiber evanescent wave spectroscopy; FID = flame ionization detection; FT-IR = Fourier transform infrared; GC = gas chromatography; HECD = Hall electrolytic conductivity detector; HRGC = high resolution gas chromatography; HSD = halide-sensitive detector; H_2SO_4 = sulfuric acid; LDPE = low-density polyethylene; MS = mass spectrometry; NIOSH = National Institute for Occupational Safety and Health; PI = photoionization; SIM = selected ion monitoring; SPME = solid-phase microextraction; UV = ultraviolet detection

Tetrachloroethylene can be detected in drinking water, groundwater, waste water, and leachate from solid waste. The primary analytical methods are separation by GC combined with detection by HECD or other type of halogen-specific detector, ECD, or MS. In most methods, tetrachloroethylene is liberated from the liquid matrix by purging with an inert gas concentrated by trapping on a suitable solid sorbent and thermally desorbed onto the gas chromatograph column. Baykut and Voigt (1992) describe a method in which tetrachloroethylene is removed from aqueous solutions using a spray extraction technique, followed by trapping on a solid sorbent, then thermal desorption onto a gas chromatograph. Detection of tetrachloroethylene is generally by HECD (or other halogen-specific detector) or MS (APHA 1992; Baykut and Voigt 1992; EPA 1982a, 1982b; Otson and Williams 1982; Wallace 1986; Wallace et al. 1986c, 1986d). The limit of detection is in the sub-ppb range for halogen-specific detectors (APHA 1992; EPA 1982a, 1982b) and in the low-ppb for MS (EPA 1982a). Accuracy is generally >90% (APHA 1992; EPA 1982a, 1982b), although lower values have been reported (Wallace 1986; Wallace et al. 1986c, 1986d). Precision is ±13% (RSD) or better (APHA 1992; EPA 1982a, 1982b; Wallace 1986; Wallace et al. 1986d). Purging directly to the gas chromatograph with whole-column cryogenic trapping has been reported (Pankow and Rosen 1988). The study authors reported excellent purging efficiency (100%) and stated that sensitivity and precision should be correspondingly good, although specific values for these parameters were not reported. Headspace analysis has been used to determine tetrachloroethylene in water samples. High accuracy and precision were reported for a procedure in which GC/ECD was the analytical method (Dietz and Singely 1979). Solid waste leachates from sanitary landfills have been analyzed for tetrachloroethylene and other volatile organic carbons (Schultz and Kjeldsen 1986). Detection limits for the procedure, which involves extraction with pentane followed by GC/MS analysis, are in the low-ppb and low-ppm ranges for concentrated and neat samples, respectively. In addition to the GC/MS analysis, liquid chromatography (LC)/MS can be useful in detecting polar, unstable, and heavy pollutants. However, this analysis is not widely used and as such, there are not many LC/MS spectra in the literature to make comparisons to (Benfenati et al. 1996).

An *in situ* method for tetrachloroethylene analysis using fiber evanescent wave spectroscopy (FEWS) has been described by Krska et al. (1993). In this method, the water flows through a glass chamber containing a silver halide fiber coated with low-density polyethylene in an amorphous phase. The coating serves to concentrate the tetrachloroethylene, and the compound is detected using infrared spectrophotometry. The detection limit of this method, which was validated using headspace GC, was 1 ppm.

Purge-trap GC coupled with atomic emission detection is also an effective way to determine tetrachloroethylene in the water.

SPME with GC/MS was used for the determination of tetrachloroethylene in soil landfill site samples. The detection limit was 2 ng/g with the retention time of 11.0 minutes (James and Stack 1996). In sediments, headspace analysis with GC/MS was utilized for the determination of tetrachloroethylene. Recoveries ranged from 50.4 to 53.5%. Sensitivity is enhanced even further by increasing concentrations of tetrachloroethylene in the headspace gas (Kawata et al. 1997).

Several procedures for determination of the chemical in plants and food were located. GC/ECD and GC/ halide-sensitive detector (HSD) are most commonly used to analyze solid samples for tetrachloroethylene contamination. Extraction, purge-and-trap, and headspace analysis have all been used to prepare samples. Analysis of headspace gases by GC coupled with ECD, MS, or HSD has proven relatively sensitive (low- to sub-ppb range) and reproducible for a variety of foods (Entz and Hollifield 1982; EPA 1982b; Pocklington 1992). It has also been used to analyze building materials and consumer products (Wallace et al. 1987). GC/HSD of headspace gases is the EPA-recommended method for solid matrices (EPA 1982b). Foods have also been analyzed for tetrachloroethylene by GC/ECD/HECD following isooctane extraction. Sensitivity was comparable to headspace methods, but reproducibility was not as good (Daft 1988). In both headspace and extraction preparation methods, increased lipid content of the matrix adversely affected accuracy and precision. A purge-and-trap technique proved useful for analyzing grains and grain-based foods with high sensitivity and good recovery (Heikes and Hopper 1986).

7.3 ADEQUACY OF THE DATABASE

Section 104(i)(5) of CERCLA, as amended, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of tetrachloroethylene is available. Where adequate information is not available, ATSDR, in conjunction with NTP, is required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of tetrachloroethylene.

The following categories of possible data needs have been identified by a joint team of scientists from ATSDR, NTP, and EPA. They are defined as substance-specific informational needs that if met would reduce the uncertainties of human health assessment. This definition should not be interpreted to mean

that all data needs discussed in this section must be filled. In the future, the identified data needs will be evaluated and prioritized, and a substance-specific research agenda will be proposed.

7.3.1 Identification of Data Needs

Methods for Determining Biomarkers of Exposure and Effect.

Exposure. Methods are available for measuring tetrachloroethylene in breath (Wallace et al. 1986a, 1986d), blood (Antoine et al. 1986; Michael et al. 1980; Ramsey and Flanagan 1982), urine (Michael et al. 1980), and adipose tissue (Chen et al. 1993; Michael et al. 1980; Ramsey and Flanagan 1982), and trichloroacetic acid in blood (Ziglio et al. 1984) and urine (Christensen et al. 1988; Pekari and Aitio 1985a, 1985b). Available methods are sensitive for measuring exposure levels at which health effects have been observed to occur (e.g., in workers known to be exposed to high levels of tetrachloroethylene). However, the best biomarkers are ones that detect levels prior to health effects. These methods have also been used to measure background levels in individuals believed not to have been exposed to higher-than-expected levels of tetrachloroethylene (e.g., office workers and housewives) (Wallace 1986). The methods are generally reliable, although increased precision for most methods would increase reliability. However, tetrachloroethylene is pervasive in the environment and background levels for the general population are not well defined. Levels may vary considerably within the environment, making it difficult to differentiate between normal background exposure and excess exposure. Further research on the relationship between levels found in living and working environments not suspected of having elevated levels of tetrachloroethylene and levels of the chemical and/or its metabolites in biological media would help in better defining background levels of the chemical and aid in determining if improved methods of monitoring exposure are needed.

Effect. There are no unique biomarkers of effect for tetrachloroethylene; however, sensitive and reliable clinical methods exist for determining damage to the liver, a target organ for tetrachloroethylene toxicity. These include measuring serum levels of liver enzymes, bilirubin, and alkaline phosphatase and urinary urobilinogen (Bagnell and Ellenberger 1977; Coler and Rossmiller 1983; Meckler and Phelps 1966; Stewart et al. 1981). Neurological effects may also result from exposure to tetrachloroethylene (Carpenter 1937; Haerer and Udelman 1964; Hake and Stewart 1977; Kendrick 1929; Koppel et al. 1985; Morgan 1969; Rowe et al. 1952; Saland 1967; Sandground 1941; Stewart et al. 1970, 1981; Wright et al. 1937). Tests for these effects are not especially sensitive, reliable, or specific and would not improve detection over the established procedures for measuring tetrachloroethylene in breath, blood, or urine.

Methods for measuring levels of tetrachloroethylene and its metabolites that might be associated with adverse health effects are the same as those for exposure. The methods are sensitive for measuring levels of tetrachloroethylene and its metabolites in individuals not exhibiting apparent health effects resulting from the chemical (Monster and Smolders 1984; Wallace 1986) as well as in those known to be affected by absorption of excessively high levels of tetrachloroethylene. However, correlations between levels of tetrachloroethylene or its metabolites detected in biological media and specific observed effects at lower levels of absorption are not well established. Additional research in this area would allow better assessment of existing methods and would help in defining areas in which improvements are needed. Improved methods of tissue analysis, giving greater sensitivity and reproducibility, would also help in determining the quantitative relationship between the observed toxic effect on specific organs and the levels of tetrachloroethylene or its metabolites in these organs.

Methods for Determining Parent Compounds and Degradation Products in Environmental Media. Existing methods for determining tetrachloroethylene in air (Krost et al. 1982; Makide et al. 1979; Rasmussen et al. 1977; Wallace et al. 1986a) and water (APHA 1992; EPA 1982a; Otson and Williams 1982), the media of most concern for human exposure, are sensitive, reproducible, and reliable for measuring background levels in the environment. Research investigating the relationship between levels measured in air and water and observed health effects could increase our confidence in existing methods and/or indicate where improvements are needed. Methods for solid matrices vary in accuracy and precision depending on the method and the matrix (e.g., sludge, soil, sediment, building material). Improved methods of detecting tetrachloroethylene in plants and foods, especially those with higher fat content, would aid in determining the contribution of tetrachloroethylene exposure from these sources. This would be especially important in determining the potential for contamination of populations living adjacent to hazardous waste sites and other potential sources of exposure to higher than background levels of tetrachloroethylene.

7.3.2 Ongoing Studies

The Environmental Health Laboratory Sciences Division of the National Center for Environmental Health, Centers for Disease Control and Prevention, is developing methods for the analysis of tetrachloroethylene and other volatile organic compounds in blood. These methods use purge and trap methodology, high-resolution gas chromatography, and magnetic sector mass spectrometry, which give detection limits in the low parts per trillion (ppt) range.