6. ANALYTICAL METHODS

The purpose of this chapter is to describe the analytical methods that are available for detecting, and/or measuring, and/or monitoring chloroethane, its metabolites, and other biomarkers of exposure and effect to chloroethane. 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.

6.1 BIOLOGICAL SAMPLES

The analytical methods for the determination of chloroethane in biological matrices are given in Table 6-1. The purge and trap method used for environmental samples is also commonly used for biological samples. The discussion regarding the methods that may be most sensitive for determining chloroethane levels in environmental samples and the advantages and disadvantages of the commonly used methods as given in Section 6.2 are also applicable for biological samples.

6.2 ENVIRONMENTAL SAMPLES

Analytical methods for the determination of chloroethane in environmental samples are presented in Table 6-2. The two common methods used for preconcentrating chloroethane in air samples are adsorption on a sorbent column and collection in a cryogenically cooled trap. The disadvantages of cryogenic cooling are that the method is cumbersome and condensation of moisture in air may block the passage of further air through the trap. The disadvantages of the sorption tubes are that the sorption and desorption efficiencies may not be 100% and that the background impurities in the sorbent tubes may interfere with the detection of samples containing low concentrations of chloroethane (Cox 1983). The most common method for determining chloroethane levels in water, sediment, soil, and aqluatic species is purging chloroethane vapor from the sample or its solution in water using an inert gas and then trapping the desorbed vapors in a sorbent

TABLE 6-1. Analytical Methods for Determining Chloroethane in Biological Samples

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Exhaled air[a]	Exhaled air collected by valved Teflon spirometer mouthpieces into Tedlar bag, content adsorbed in Tenax, thermal desorption	Cryofocus-sing HRGC-FID/MS	No data	No data	Pellizzari et al. 1987
Human milk	Purged at 70°C and trapped in Tenax, thermal desorption	Cryofocus-sing HRGC-FID/MS	No data	No data	Michael et al. 1980; Pellizzari et al. 1982
Blood and urine	Mixed with water and antifoaming agent, purged at 50°C, trapped in Tenax, thermal desorption	Cryofocus-sing HRGC-FID/MS	3 µg/L (blood); 3 µg/L (urine)	>80%	Michael et al. 1980[b]; Pellizzari et al. 1979[b]
Urine	Add NaH_2PO_4 to dried sample and add acylase solution. Incubate, deproteinize. Separate by cation exchange.	HPLC 340 nm	7 µg/L	94.2	Eškinja et al. 1997
Adipose tissue	Tissue homogenized, purged at 50°C, trapped in Tenax, thermal desorption	Cryofocus-sing HRGC-FID/MS	No data	No data	Michael et al. 1980; Pellizzari et al. 1979

[a]The method was not used for the quantification of chloroethane, but other halogenated hydrocarbons were quantified.

[b]The methods in these studies were not used for the quantification of chloroethane, but structurally-similar chlorinated organics were analyzed. Although not previously tested, these methods should work for chloroethane. Detection limits and recovery percentages are provided for purposes of comparison only.

FID = flame ionization detector; HRGC = high resolution gas chromatography; MS = mass spectrometry; HPLC = high performance liquid chromatography

TABLE 6-2. Analytical Methods for Determining Chloroethane in Environmental Samples

Sample matrix	Sample preparation	Analytical method	Sample detection limit	Percent recovery	Reference
Ambient air	Collected in electropolished stainless steel canister and preconcentrated in a liquid oxygen-cooled trap	GC-EC	$<5.0\times10^{-6}$ ppm	No data	Singh et al. 1983
	Direct injection	Subambient GC-MS	$<5.0\times10^{-6}$ ppm	No data	Grimsrud and Rasmussen 1975
	Collected in cryogenically cooled trap, vaporized and adsorbed onto Tenax, thermal desorption	GC-MS	$>1.4\times10^{-5}$ ppm[a]	100% (assumed by study author)	Shepson et al. 1987
	Collect air in sorbent trap. Heat trap, desorb gas and vapor. Purge with helium.	GC-MS (ion trap)	810 ppm	---	Oliver et al. 1996
Air	Adsorbed on charcoal tubes, desorbed by carbon disulfide	GC-FID (NIOSH Method 2519)	0.01 mg per sample	≈101% at 485–1940 ppm (1300–5200 mg/m^3)	NIOSH 1994a NIOSH 1994a
Air from contaminated site	Adsorbed on Tenax, thermal desorption	Cryofocussing HRGC-MS	No data	No data	Hauser and Bromberg 1982
Air from landfill	Adsorbed on Tenax-silica gel, thermal desorption	Cryofocussing HRGC-MS	10^5 ppm	No data	Vogt and Walsh 1985
Raw/treated water	Purge and trap, and thermal desorption	GC-MS	<1 µg/L	90%	Otson 1987

TABLE 6-2. Analytical Methods for Determining Chloroethane in Environmental Samples (*continued*)

Sample matrix	Sample preparation	Analytical method	Sample detection limit	Percent recovery	Reference
Finished drinking/raw source water	Purge at ambient temperature, trap in Tenax/silica gel/charcoal and thermal desorption	GC-HECD (EPA Method 502.1)	0.008 µg/L	93% at 0.4 µg/L	EPA 1986b
Finished drinking/raw source water	Purge at ambient temperature, trap in Tenax/silica gel/charcoal and thermal desorption	Subambient GC-MS (EPA Method 524.1)	No data	No data	EPA 1986b EPA 1986b
Water	Purge at ambient temperature, trap in Tenax/silica gel/charcoal, thermal desorption	Cryofocussing HRGC-MS (EPA Method 524.2)	0.10 µg/L (wide-bore column); 0.02 µg/L (narrow bore column)	89% (wide bore) at 0.5–10 µg/L; 100% (narrow bore) at 0.1 µg/L	EPA 1986b
	Purge at ambient temperature, whole column cryotrapping	HRGC (wide bore capillary) - MS	No data	No data	Pankow and Rosen 1988
	Purge at 35°C, trap in Tenax/ Ambersorb 340/silica/charcoal, thermal desorption	Cryofocussing HRGC-MS	0.4 µg/L	42% at 32.9 µg/L	Otson and Chan 1987
Water/waste water	Purge at ambient temperature, trap in Tenax/silica gel/charcoal, thermal desorption	GC-HECD (EPA Method 601)	0.52 µg/L	91.5%	EPA 1988a
Waste water	Purge at ambient	GS-MS (EPA	No data	97–103%	EPA 1988b

TABLE 6-2. Analytical Methods for Determining Chloroethane in Environmental Samples (*continued*)

Sample matrix	Sample preparation	Analytical method	Sample detection limit	Percent recovery	Reference
	temperature, trap in Tenax/silica gel, thermal desorption	Method 624)			
Groundwater	Purge at ambient temperature, trap in Tenax/silica gel, thermal desorption	GC-MS	10 µg/L	No data	EPA 1986b
Water/fish	Dry purge and trap (water); sonicated slurry subjected to dry purge and trap (fish)	Cryofocussing HRGC-HECD/PID in series	No data	No data	Driscoll et al. 1987
Fish	Homogenized in blender, mix in water, purge at 80°C, trap in Tenax, thermal desorption	GC-MS	<0.3 µg/kg (wet weight)	60–90%	Young et al. 1983
Fish	Vacuum distillation	Cryofocussing HRGC-MS	No data	No data	Hiatt 1983
Marine biota/ sediment	Homogenize biota ultra-sonically, mix with water, purge at 70°C, trap in Tenax/silica gel, thermal desorption	Subambient focussing HRGC-MS	No data	No data	Ferrario et al. 1985
Soil and sediment	Purge suspension in water at 50°C, trap in Tenax/silica, thermal desorption	GC-MS	10 µg/kg	No data	EPA 1986b

TABLE 6-2. Analytical Methods for Determining Chloroethane in Environmental Samples (*continued*)

Sample matrix	Sample preparation	Analytical method	Sample detection limit	Percent recovery	Reference
Liquid and liquid waste	Disperse sample in glycol, purge at ambient temperature, trap in Tenax/silica gel/charcoal, thermal desorption	GC-HECD (EPA Methods 5030 and 8010)	0.008 µg/L (method detection limit)	No data	EPA 1994
Solid and liquid waste	Disperse sample in glycol, purge at ambient temperature, trap in Tenax/silica gel/charcoal, thermal desorption	GC-HECD/PID in series	1000–5000 µg/kg (soil)	No data	Lopez-Avila et al. 1987

[a]Estimated value from the impurity in blank tube, a sampling volume of 50 L and the detection limit being twice the blank level.

EC = electron capture detector; EPA = Environmental Protection Agency; FID = flame ionization detector; GC = gas chromatography; HECD = Hall electrolyte conductivity detector; HPLC = high performance liquid chromatography; HRGC = high resolution gas chromatography; MS = mass spectrometry; NIOSH = National Institute for Occupational Safety and Health; PID = photoionization detector; GC/MS = gas chromatography/mass spectrometry

trap. Subsequent thermal desorption is used for the quantification of its concentration. The two analytical instruments that provide the lowest detection limits are the halide-specific detectors (e.g., Hall electrolytic conductivity detector) and the mass spectrometer (see Table 6-2). The advantages of halide-specific detectors are that they are not only very sensitive, but they are also specific for halide compounds. The mass spectrometer, however, provides an additional confirmation of the presence of a compound through the ionization patterns and is desirable when a variety of compounds are to be quantified. High-resolution gas chromatography with capillary columns is a better method for volatile compounds than chromatography with packed columns because capillary columns provide better resolution of closely eluting compounds and increase the sensitivity of detection. In addition, purge and whole column cryotrapping eliminates the need for the conventional purge and trap unit and reduces the time of analysis (Pankow and Rosen 1988). The plugging of the trap by the condensation of moisture during cryotrapping may be avoided by using a wide bore capillary column, although the chromatographic resolution of such a column is inferior to narrow bore capillary columns (Mosesman et al. 1987; Pankow and Rosen 1988).

6.3 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 chloroethane is available. Where adequate information is not available, ATSDR, in conjunction with the 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 chloroethane.

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.

6.3.1 Identification of Data Needs

Methods for Determining Parent Compounds and Metabolites in Biological Materials. There is a relative paucity of data on the analytical methods for the determination of chloroethane levels, as well as levels of its metabolites, in biological matrices. Most of the limited number of publications that discuss the methods for the determination of organic volatiles in biological matrices (Michael et al. 1989; Pellizzari et al. 1979) are not specific for chloroethane. These studies analyze other structurally-similar chlorinated hydrocarbons and discuss the applicability of the techniques for measuring other hydrocarbons. Therefore, it is believed that these techniques would be useful for the detection of chloroethane in certain biological matrices. However, recovery data and detection limits have not been conclusively determined for chloroethane at this time. Further studies to develop analytical methodologies for the determination of chloroethane in biological matrices are needed.

One study was identified which described the assay of a chloroethane metabolite in human urine (ESkinja et al. 1997). This study measured the concentration of ethylmercapturic acid (EMA), a metabolite of glutathione conjugation of chloroethane, in urine from subjects presumably exposed to chloroethane. Themethod is fairly sensitive, with detection limits in the ppb range.

Methods for Determining Biomarkers of Exposure and Effect. No known biomarker for this chemical in human tissue or body fluids has been identified. Ethylmercapturic acid, a metabolite of glutathione conjugation of chloroethane, can be detected in human urine. However, this metabolite can be formed by glutathione conjugation to other structurally-similar compounds and is not specific to chloroethane exposure. The potential usefulness of this compound as an indicator of exposure needs to be investigated further. Additional studies to identify specific biomarkers and to develop analytical monitoring methodologies for the determination of chloroethane exposure are needed. One breath absorption study using inhaled radiolabeled chloroethane quantitatively measured absorption of the compound (Morgan et al. 1970). However, the analytical technique used is not applicable for widespread use because it involved quantitative analysis of the radiolabel, not the compound itself.

Methods for Determining Parent Compounds and Degradation Products in Environmental Media. Analytical methods with adequate sensitivity and specificity are available for the quantification of chloroethane in environmental samples (Driscoll et al. 1987; EPA 1982a, 1986b; Ferrario et al. 1985; Hiatt 1983; Lopez-Avila et al. 1987; Otson and Ghan 1987; Shepson et al. 1987; Vogt and Walsh 1985). The degradation products of chloroethane are ethanol and chloride salts (the hydrochloric acid initially formed dissociates to form chloride salts at the neutral pH values in most environmental media). Analysis for these compounds in environmental media would provide little or no information about chloroethane.

6.3.2 Ongoing Studies

No significant ongoing studies are in progress for the development of analytical methodologies for chloroethane and its metabolites in biological media or for chloroethane and its degradation products in environmental media.