

7. ANALYTICAL METHODS

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

Atomic absorption spectrophotometry (AAS) is the most common analytical procedure for measuring arsenic in biological materials (Curatola et al. 1978; Foà et al. 1984; Johnson and Farmer 1989; Mushak et al. 1977; Norin and Vahter 1981; Sotera et al. 1988). In AAS analysis, the sample is heated in a flame or in a graphite furnace until the element atomizes. The ground-state atomic vapor absorbs monochromatic radiation from a source and a photoelectric detector measures the intensity of transmitted radiation (APHA 1989b). Inductively-coupled plasma atomic emission spectrometry (ICP-AES) and ICP-mass spectrometry (ICP-MS) are increasingly common techniques for the analysis of arsenic; both methods can generally provide lower detection limits than absorbance detection methods.

Samples may be prepared for AAS in a variety of ways. Most often, the gaseous hydride procedure is employed (Curatola et al. 1978; Foà et al. 1984; Johnson and Farmer 1989; Norin and Vahter 1981). In this procedure, arsenic in the sample is reduced to arsine (AsH_3), a gas that is then trapped and introduced into the flame. This approach measures total inorganic arsenic, but may not detect all organic forms unless preceded by a digestion step. Digestion or wet-ashing with nitric, sulfuric, and/or perchloric acids degrades the organic arsenic species to inorganic arsenic so that recovery of total arsenic from biological materials can be achieved (Maher 1989; Mushak et al. 1977; Versieck et al. 1983). In microwave assisted digestion, harsh oxidation conditions are used in conjunction with microwave heating (Benramdane et al. 1999b). For accurate results, it is important to check the completeness of the oxidation; however, this is seldom done (WHO 1981).

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The arsenic concentration in biological fluids and tissues may also be determined by neutron activation analysis (NAA) (Landsberger and Simsons 1987; Versieck et al. 1983). In this approach, the sample is irradiated with a source of neutrons that converts a portion of the arsenic atoms to radioactive isotopes, which can be quantified after separation from radioisotopes of other chemicals. Neutron activation has limited use because of the limited number of nuclear reactors in the United States providing this service and the need to dispose of radioactive waste. X-ray fluorescence is also capable of measuring arsenic in biological materials (Bloch and Shapiro 1986; Clyne et al. 1989; Nielson and Sanders 1983) and environmental samples (see Section 7.2). This method has the advantage that no sample digestion or separation steps are required. Hydride generation combined with atomic fluorescence spectroscopy (HG-AFS) is a relatively new technique that provides freedom from interference offered by hydride generation with sensitivity better than to 20 parts per trillion and linearity up to 10 ppm (PSA 2000).

Speciation of arsenic (i.e., analysis of organic arsenic compounds or different inorganic species, rather than total arsenic) is usually accomplished by employing separation procedures prior to introduction of the sample material into a detection system. Various types of chromatography or chelation-extraction techniques are most commonly used in combination with AAS, ICP-AES, or ICP-MS detection methods (Dix et al. 1987; Foà et al. 1984; Johnson and Farmer 1989; Mushak et al. 1977; Norin et al. 1987; Thomas and Sniatecki 1995). In one method, high performance liquid chromatography (HPLC) is combined with HG-AFS to quantify As(III), dimethylarsinic acid (DMA), monomethyl arsonic acid (MMA), and As(V) (PSA 2000). Another approach involves selective reduction of arsenate and arsenite (permitting quantification of individual inorganic arsenic species), and selective distillation of methyl arsines to quantify MMA and DMA (Andreae 1977; Braman et al. 1977; Crecelius 1978). Most methods for measuring arsenic in biological samples are unable to measure arsenobetaine with any accuracy because it does not form a hydride and it gives a different response from inorganic arsenic in electrothermal AAS. Ebdon et al. (1999) successfully employed HPLC coupled with ICP-MS to determine arsenic speciation in blood plasma, which was entirely arsenobetaine. Øygaard et al. (1999) developed a simple method to determine inorganic arsenic in biological samples. Their method, which involves initially distilling inorganic arsenic from the sample as AsCl_3 using HCl, avoids separating and quantifying all of the different arsenic species, which is both costly and time-consuming.

Table 7-1 summarizes a variety of methods for measuring total arsenic and individual arsenic species in biological materials. None of these methods have been standardized by EPA or other federal agencies.

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Table 7-1. Analytical Methods for Determining Arsenic in Biological Samples

| Sample matrix | Preparation method | Analytical method | Sample detection limit | Percent recovery | Reference |
|--|---|-------------------------|--------------------------|------------------|------------------------------|
| <i>Methods for total arsenic:</i> | | | | | |
| Blood | Digestion with nitric acid and hydrogen peroxide; dry ash with magnesium oxide/magnesium nitrate; reduction with sodium borohydride | HGAAS | 0.5 µg/L | 95–102 | Foà et al. 1984 |
| Blood, hair | Wet ash with nitric/perchloric acids; reduction with sodium borohydride | HGAAS | 0.1 µg/L ^a | 95–105 | Valentine et al. 1979 |
| Serum | Irradiation; digestion with nitric/perchloric/sulfuric acids; extraction with toluene | NAA | 0.088 ng/mL ^a | 94–98 | Versieck et al. 1983 |
| Urine | Irradiate epidermally | NAA | 40–100 ng/g | 93–109 | Landsberger and Simsons 1987 |
| Urine | Digestion with nitric and perchloric acid; reduction with tin chloride; generation arsine by addition of zinc; reaction with SDDC | Colorimetric photometry | 0.5 µg/sample | 90–110 | Pinto et al. 1976 |
| Urine | Pretreatment with L-cysteine; reduction with potassium iodide/ascorbic acid | Flow injection HGAAS | 0.1 µg/L | 95–100 | Guo et al. 1997 |
| Urine | Drying sample; irradiation with x-rays | XRF | 0.2 µg/L ^a | 92–108 | Clyne et al. 1989 |
| Hair | Wet ashing with nitric/sulfuric acids and hydrogen peroxide; reduction to arsine with sodium borohydride | HGAAS | 0.06 µg/g | 93 | Curatola et al. 1978 |
| Soft tissue | Digestion with nitric/sulfuric acids; complexation with DDDC in potassium iodide; extraction with chloroform | GFAAS | 0.2 ppm | 79.8 | Mushak et al. 1977 |
| Nails | Wet ashing with nitric/sulfuric acids and hydrogen peroxide; reduction to arsine with sodium borohydride | HGAAS | 1.5 µg/g | No data | Agahian et al. 1990 |
| <i>Methods for arsenic speciation:</i> | | | | | |
| Urine | Separation of As ⁺³ , As ⁺⁵ , MMA, and DMA on anion/cation exchange resin column; reduction to respective arsines with sodium borohydride | IEC/HGAAS | 0.5 µg/L | 93–106 | Johnson and Farmer 1989 |
| Urine | Reduction of As ⁺³ , As ⁺⁵ , MMA, and DMA to arsines with sodium borohydride | HGAAS | 0.08 µg/L | 97–104 | Norin and Vahter 1981 |

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| Sample matrix | Preparation method | Analytical method | Sample detection limit | Percent recovery | Reference |
|--------------------------------------|---|---|-----------------------------|---|----------------------------|
| Urine | Reduction of As ⁺³ , As ⁺⁵ , MMA, and DMA to arsines; collection in cold trap; selective distillation by slow warming | Atomic emission (direct-current plasma) | ≤1 ng for all four species | No data | Braman et al. 1977 |
| Urine | Extraction with chloroform/methanol; column separation with chloroform/methanol; elution on cation exchange column with ammonium hydroxide | HGAAS/TLC/HRMS | 0.34 mg/sample ^a | No data | Tam et al. 1982 |
| Blood/tissue | Acidification with hydrochloric acid; complexation with TGM; extraction into cyclohexane; separation on capillary column | GLC/ECD | 0.1 mg/mL | No data | Dix et al. 1987 |
| Blood plasma | Separation by HPLC | HPLC/ICP-MS | 2.5 ng As/mL | ~100 | Ebdon et al. 1999 |
| Urine | Separation by anion exchange chromatography; detection by direct coupling of column to ICP-MS | IEC/ICP-MS | <0.45 µg/L for all species | No data | Inoue et al. 1994 |
| Marine biota | Extraction with methanol-water; removal of fats by liquid-liquid extraction or solid-phase cartridge | HPLC/ICP-MS | 6–25 ng/mL | 94.6 (fish muscle CRM) | Sniatecki 1994 |
| Marine biota | Separation by anion exchange coupled with HPLC; on-line microwave oxidation | HPLC/HGAAS | 0.3–0.9 ng | 95–110 (recovery of spike in fish tissue) | López-González et al. 1994 |
| Biological samples—Inorganic arsenic | Distill inorganic arsenic as AsCl ₃ using HCl after prereduction of As(V) with KI/HCl | Flow-injection HGAAS | 0.045 mg/kg (dry matter) | No data | Øygard et al. 1999 |

^aLowest reported concentration

CRM = certified reference material; DDDC = diethylammonium diethyldithiocarbamate; DMA = dimethylarsinate; ECD = electron capture detector; GFAAS = graphite furnace atomic absorption spectrometry; GLC = gas-liquid chromatography; HGAAS = hydride generation atomic absorption spectrometry; HRMS = high resolution mass spectrometry; ICP-MS = inductively-coupled plasma mass spectrometry; IEC = ion exchange chromatography; HPLC = high-performance liquid chromatography; MMA = monomethylarsonate; NAA = neutron activation analysis; SDDC = silver diethyldithiocarbamate; TGM = thioglycolic acid methylester; TLC = thin layer chromatography; XRF = x-ray fluorescence

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Detection limits in blood and urine are about 0.1–1 ppb for most techniques; limits for hair and tissues are usually somewhat higher.

7.2 ENVIRONMENTAL SAMPLES

Arsenic in environmental samples is also measured most often by AAS techniques, with samples prepared by digestion with nitric, sulfuric, and/or perchloric acids (Dabeka and Lacroix 1987; EPA 1983b, 1994a, 1994b; Hershey et al. 1988). Other methods employed include a spectrophotometric technique in which a soluble red complex of arsine and silver diethyldithiocarbamate (SDDC) is formed (APHA 1977; EPA 1983c, 1983d), ICP-AES (EPA 2000c; NIOSH 2003), graphite furnace AAS (EPA 1983b, 1994b; NIOSH 1994b), ICP-MS (EPA 1991, 1994a, 1998j), and x-ray fluorescence (Khan et al. 1989; Nielson and Sanders 1983).

HPLC is currently the most common technique for separation of the species of arsenic found in seafood (Benramdane et al. 1999b; Guerin et al. 1999; Kumaresan and Riyazuddin 2001). An advantage of HPLC over other separation methods (e.g., gas chromatography [GC]) is that the arsenic species do not need to be derivatized prior to separation, avoiding concerns over complete conversion to the derivative for detection.

Since arsenic in air is usually associated with particulate matter, standard methods involve collection of air samples on glass fiber or membrane filters, acid extraction of the filters, arsine generation, and analysis by SDDC spectrophotometry or AAS (APHA 1977; NIOSH 1984).

Methods standardized by the EPA for measuring total arsenic in water and waste water, solid wastes, soil, and sediments include: ICP-MS (EPA 1998j, 1994a, 1991), ICP-AES (EPA 1996d), graphite furnace AAS (EPA 1994b), quartz furnace hydride generation AAS (EPA 1996h), and an electrochemical method using anodic stripping voltammetry (ASV) (EPA 1996e). A modification using cryogenic GC to EPA Method 1632 (HG/AAS) allows the technique to be adopted for the species As(III), As(V), MMA, and DMA to the 0.003 ppb level (EPA 1998l). Similar methods are recommended by APHA for water using AAS/hydride generation (APHA 1989c), AAS/graphite furnace technique (APHA 1989b), ICP (APHA 1989d), or SDDC spectrophotometry (APHA 1989a). The AAS/hydride generation method is generally resistant to matrix and chemical interferences (APHA 1989a). Techniques to compensate for these interferences have been described by EPA (1982b).

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Analysis for arsenic in foods is also most frequently accomplished by AAS techniques (Arenas et al. 1988; Dabeka and Lacroix 1987; Hershey et al. 1988; Tam and Lacroix 1982). Hydride generation is the sample preparation method most often employed (Arenas et al. 1988; Hershey et al. 1988), but interferences must be evaluated and minimized.

Speciation of inorganic arsenic in environmental samples is usually accomplished by chromatographic separation, chelation-extraction or elution of As(III), and then reduction of As(V) with subsequent similar treatment (Butler 1988; López-González et al. 1994; Mok et al. 1988; Rabano et al. 1989).

Methods are also available for quantifying organic arsenicals in environmental media, including arsenobetaine in fish (Beauchemin et al. 1988; Cannon et al. 1983) and other organic forms of arsenic in water, soil, and foods using hyphenated methods of separation and detection (HPLC/ICP-MS, HPLC/HGAAS, IC/ICP-MS) (Andreae 1977; Braman et al. 1977; Comber and Howard 1989; Crecelius 1978; Heitkemper et al. 1994; López-González et al. 1994; Odanaka et al. 1983; Teräsahde et al. 1996).

Methods have been developed for extraction of arsenic species from solid seafood samples that included treatment of the sample with mixtures of organic solvents (alcohols or chloroform) and water to extract the arsenic compounds that are soluble in water or polar organic solvents. These extracts can be subsequently analyzed by HPLC. Enzymatic digestion using trypsin has also been used to extract arsenic compounds from seafood samples (Benramdane et al. 1999b). These extraction techniques are used in place of digestion when speciated data are needed.

A summary of selected methods for analysis of total arsenic and individual inorganic and organic arsenic species in environmental samples is presented in Table 7-2.

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 arsenic 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 arsenic.

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

| Sample matrix | Preparation method | Analytical method | Sample detection limit | Percent recovery | Reference |
|--|--|--|------------------------|------------------|------------------------|
| <i>Methods for total arsenic:</i> | | | | | |
| Air (particulates) | Collection on cellulose ester membrane filter; digestion with nitric acid, sulfuric acid, and perchloric acid | NIOSH Method 7900; HGAAS | 0.02 µg/sample | No data | NIOSH 1994a |
| Air (particulate arsenic and arsenic trioxide vapor) | Collection on Na ₂ CO ₃ -impregnated cellulose ester membrane filter and H ₂ O ₂ | NIOSH Method 7901; GFAAS | 0.06 µg/sample | No data | NIOSH 1994b |
| Air | Collection on cellulose ester membrane filter; digestion with nitric acid, sulfuric acid, and perchloric acid | NIOSH Method 7300; ICP-AES | 0.140 µg/filter | No data | NIOSH 2003 |
| Water/waste water/solid wastes | Acid digestion | EPA Method 6010C; ICP-AES | 35 µg/L | 86 | EPA 2000c |
| Water/waste water/solid wastes | Digestion with nitric and hydrochloric acids | EPA Method 200.7; ICP-AES | 8 µg/L | 106 | EPA 1994c |
| Water/soil/solid waste | Digestion with nitric acid and hydrogen peroxide | EPA Methods 206.2 and 7060A; GFAAS with Ni(NO ₃) ₂ modifier | 1 µg/L | 85–106 | EPA 1983b, 1994b |
| Water/waste water/solid waste | Digestion with nitric acid | EPA Methods 200.8, 6020 and 6020A ICP-MS | 0.4 µg/L | 97–114 | EPA 1991, 1994a, 1998j |
| Water/soil/solid waste | Digestion with nitric/sulfuric acid; reduction to As ⁺³ with tin chloride; reduction to arsine with zinc in acid solution | EPA Method 206.3 | 2 µg/L | 85–94 | EPA 1983c |
| Water | Reduction to arsine in acid solution; reaction with SDDC | EPA Method 206.4; SDDC colorimetric spectrophotometry at 510 nm | 10 µg/L | 100 | EPA 1983d |
| Water | Digestion with 6M HCl; reduction to arsine with sodium borohydride; cold trap and desorption into quartz furnace | EPA Method 1632; HGAAS | 2 ng/L | No data | EPA 1998l |

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

| Sample matrix | Preparation method | Analytical method | Sample detection limit | Percent recovery | Reference |
|---|--|---|------------------------|---|--------------------------|
| Food | Digestion with nitric acid; dry ashing with magnesium oxide; reduction with ascorbic acid; precipitation with APDC in presence of nickel carrier | GFAAS | 10 ng | 86–107 | Dabeka and Lacroix 1987 |
| Food | Digestion with nitric/sulfuric/perchloric acids; reduction to trivalent arsenic with potassium iodide; reduction to arsine with sodium borohydride | HGAAS | 0.1 µg/g | 98–110 | Hershey et al. 1988 |
| Soil, rock, coal | Preparation of pellet | XRF (backscatter) | 4 mg/kg | SRM recoveries: 110±4 in soil; 100±1 in rock; 97±18 in coal | Nielson and Sanders 1983 |
| <i>Methods for species of arsenic:</i> | | | | | |
| Air (particulate organo-arsenals) | Collection on PTFE filter | NIOSH Method 5022; ion chromatography/HGAAS | 0.2 µg As/sample | No data | NIOSH 1994c |
| Air (arsine) | Collection on coconut shell charcoal; digestion with nitric acid | NIOSH Method 6001; GFAAS | 0.004 µg/sample | No data | NIOSH 1994d |
| Air particulates (As ⁺³ and As ⁺⁵ only) | Collection on PTFE filter in high volume dichotomous virtual impactor; desorption with ethanolic hydrochloric acid; selective reduction of As ⁺³ to arsine with zinc in acid and reduction of As ⁺⁵ to arsine with sodium tetrahydroborate | HGAAS | 1 ng/m ³ | 95±7 (As ⁺³); 100±8 (As ⁺⁵) on spiked materials | Rabano et al. 1989 |
| Water | Selective elution of As ⁺³ with orthophosphoric acid; elution and conversion of As ⁺⁵ to As ⁺³ with sulfur dioxide | IEC/amperometric detector (detects As ⁺³ only) | 0.9 µg/L | 95% of converted As ⁺⁵ recovered | Butler 1988 |
| Water/soil | Selective complexation of As ⁺⁵ with ammonium molybdate; extraction with isoamyl alcohol to separate from As ⁺³ | Colorimetric spectrometry at 712 nm | No data | No data | Brown and Button 1979 |

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

| Sample matrix | Preparation method | Analytical method | Sample detection limit | Percent recovery | Reference |
|--|--|---------------------------------|-------------------------|---------------------------------|------------------------|
| Water | Selective extraction of As ⁺³ with APDC into chloroform; back extraction with nitric acid; reduction of As ⁺⁵ to As ⁺³ with thiosulfate and extract | NAA | 0.01 ppb | No data | Braman et al. 1977 |
| Food (arsenobetaine in fish) | Extraction of arsenobetaine with methanol/chloroform; digestion with nitric acid/magnesium nitrate for remainder of As species | HPLC/ICP-MS | 0.3 ng as arsenobetaine | 101±4 recovery of arsenobetaine | Beauchemin et al. 1988 |
| Water/waste water/soil (inorganic species) | Acidification or digestion with hydrochloric acid | EPA Method 7063; ASV | 0.1 µg/L | 96–102 | EPA 1996e |
| Water (As(III), As(V), MMA, and DMA) | Cryogenic GC, Digestion with 6M HCl; reduction to arsine with sodium borohydride; cold trap and desorption into quartz furnace | EPA Method 1632 appendix; HGAAS | 3 ng/L | No data | EPA 1998I |
| Water | Reduction to arsines; cold trap and selectively warm to separate arsine species | AAS | 2 ng/L | 91–109 | Andreae 1977 |
| Water | Reduction of MMA, DMA and inorganic As (control pH to select As ⁺³ or As ⁺⁵) to arsines with sodium tetrahydroborate; cold trap and selectively warm to separate arsine species | HGAAS | 0.019–0.061 ng | No data | Comber and Howard 1989 |
| Water/soil | Extraction with sodium bicarbonate; reduction of inorganic arsenic, MMA and DMA to hydrides with sodium borohydride; cold trap arsines in n-heptane | HG-HCT/GC-MID | 0.2–0.4 µg/L | 97–102 | Odanaka et al. 1983 |

AAS = atomic absorption spectrophotometry; APDC = ammonium pyrrolidine dithiocarbamate; ASV = anodic stripping voltammetry; DMA = dimethylarsinate; EPA = Environmental Protection Agency; GC-MID = gas chromatography-multiple ion detection; GFAAS = graphite furnace atomic absorption spectrometry; HGAAS=hydride generation-atomic absorption spectroscopy; HG-HCT = hydride generation-heptane cold trap; HPLC = high performance liquid chromatography; ICP-AES = inductively coupled plasma-atomic emission spectrometry; ICP-MS = inductively coupled plasma-mass spectrometry; IEC = ion exchange chromatography; MMA = monomethylarsonate; NAA = neutron activation analysis; NIOSH = National Institute of Occupational Safety and Health; PTFE = polytetrafluoroethylene; SDDC = silver diethyldithiocarbamate; SRM = standard reference material; XRF = x-ray fluorescence

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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. The most common biomarker for arsenic exposure is analysis of total arsenic in urine (Hughes 2006). Existing methods are sufficiently sensitive to measure background levels of arsenic in various tissues and biological fluids for average persons, and to detect increases as a result of above-average exposure (Agahian et al. 1990; Clyne et al. 1989; Curatola et al. 1978; Foà et al. 1984; Gebel et al. 1998b; Landsberger and Simsons 1987; Mushak et al. 1977; Pinto et al. 1976; Valentine et al. 1979; Versieck et al. 1983). The precision and accuracy of these methods are documented. Methods are also available that can distinguish nontoxic forms of arsenic (arsenobetaine) from inorganic and organic derivatives that are of health concern (Braman et al. 1977; Dix et al. 1987; Johnson and Farmer 1989; Norin and Vahter 1981; Tam et al. 1982). Further efforts to improve accuracy, reduce interferences, and detect multiple species using a single analysis would be valuable. Arsenic is believed to act by inhibition of numerous cellular and molecular processes. However, these effects are not specific to arsenic, and most can only be measured in tissue extracts.

Methods for Determining Parent Compounds and Degradation Products in Environmental Media. Arsenic is ubiquitous in the environment. It is found in air, water, soil, sediments, and food in several inorganic and organic forms. Analytical methods exist for the analysis of arsenic species in all of these environmental media, and these methods have the sensitivity to measure background levels and to detect elevated concentrations due to emissions from sources such as smelters, chemical plants, or hazardous waste sites (APHA 1977, 1989c; EPA 1982b, 1983b, 1983c, 1983d, 1991, 1994b, 1994c, 1996f, 1996h, 1998j, 2000c; NIOSH 1994a, 1994b, 2003). However, further research to reduce chemical and matrix interferences may improve the speed and accuracy of the analyses.

Le et al. (2004) pointed out that there is a need for the development of certified reference materials (CRMs) for speciation analysis. A shortcoming of many CRMs is that they are only certified for the total concentration of arsenic, and only limited information is available on the identity and concentrations of specific arsenic species in some CRMs.

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Continued improvement of the methods for determination of the particular species of arsenic, rather than just the total arsenic concentration, present in foods, especially seafood, is needed since different arsenic species poses different hazards to individuals consuming these foods.

7.3.2 Ongoing Studies

The information in Table 7-3 was found as a result of a search of the Federal Research in Progress database (FEDRIP 2006).

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Table 7-3. Ongoing Studies on Analytical Methods for Arsenic in Environmental and Biological Samples

| Investigator | Affiliation | Research description | Sponsor |
|--------------|---|--|------------------------------|
| Styblo, M | University of North Carolina Chapel Hill, Chapel Hill, North Carolina | Optimized hydride generation system for arsenic analysis | Fogarty International Center |
| Dietze, WT | Tracedetect, Inc., Seattle, Washington | A continuous monitor for arsenic in drinking water | NIEHS |
| Dasgupta, PK | Texas Tech University, Department of Chemistry, Lubbock, Texas | A green fieldable analyzer for arsenic | NSF |

NIEHS = National Institute of Environmental Health Sciences; NSF = National Science Foundation

Source: FEDRIP 2006