BIBLIOGRAPHY ON SAMPLING GROUND WATER FOR ORGANIC COMPOUNDS

By Jacob Gibs, Thomas E. Imbrigiotta, and Kenneth Turner

U.S. GEOLOGICAL SURVEY

Open-File Report 90-564

West Trenton, New Jersey

1990

U.S. DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
Mountain View Office Park
Suite 206
810 Bear Tavern Road
West Trenton, NJ 08628

Copies of this report can be
purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Box 25425
Denver Federal Center
Denver, CO 80225

CONTENTS

BIBLIOGRAPHY ON SAMPLING GROUND WATER FOR ORGANIC COMPOUNDS

By Jacob Gibs, Thomas E. Imbrigiotta, and Kenneth Turner

ABSTRACT

Selected references applicable to the collection and analysis of representative samples of ground water for trace levels of organic compounds are presented in this report. The references were obtained from lists used during four workshops on "Sampling Ground Water for Organic Compounds" conducted by the U.S. Geological Survey in 1987 and 1988. The 128 references are organized into 12 topics: sampling devices, ground-water-sampling techniques, analysis of organic vapor(s) in soil, effects of materials on sorption and desorption, well drilling and installation, degradation of organic compounds, well purging, safety, well-network design, analytical methods for organic compounds, transport of organic compounds, and miscellaneous references.

INTRODUCTION

Interest in sampling techniques has increased because of possible contamination of the nation's ground-water resources by organic compounds. The wide range of physical and chemical properties exhibited by organic compounds cause their fate and transport in ground water to be different from the fate and transport of common inorganic cations and anions. The reliable collection of representative samples of ground water containing organic compounds requires the use of specialized sampling equipment, sampling techniques, and sample-handling procedures.

In order to disseminate information on these subjects to investigators currently involved in studies of contamination of ground water by organic compounds, four workshops entitled "Sampling Ground Water for Organic Compounds" were conducted by the U.S. Geological Survey. The workshops were held in Trenton, New Jersey, May 11-15, 1987; in Miami, Florida, November 16-20, 1987; in San Antonio, Texas, February 29-March 4, 1988; and in Sacramento, California, December 12-16, 1988. The topics discussed at these workshops cover a wide range of subjects relating to the sampling of ground water for organic compounds and could be used to plan future training courses. The references cited during the workshop presentations comprise a valuable resource for the planning of future ground-water-contamination studies.

Purpose and Scope

This report presents selected references relating to the equipment, techniques, and procedures used to sample ground water for organic compounds. The report includes 128 references that pertain to the collection and analysis of representative samples of ground water for trace amounts of organic compounds.

The 128 references are organized into 12 categories that correspond to the major topics discussed at the workshops--

1. Sampling devices
2. Ground-water-sampling techniques
3. Analysis of organic vapors in soil
4. Effects of materials on sorption and desorption
5. Well drilling and installation
6. Degradation of organic compounds
7. Well purging
8. Safety
9. Well-network design
10. Analytical methods for organic compounds
11. Transport of organic contaminants
12. Miscellaneous references.

The report also includes the topics covered in the workshops and their organization. The workshop agendas are listed in appendixes A through D.

Acknowledgments

The following U.S. Geological Survey personnel contributed references which were included in this bibliography as part of their participation in the workshops: Arthur L. Baehr, Edward R. German, Keith R. Prince, Robert E. Broshears, Joseph H. Hochreiter, Thomas E. Reilly, Robert C. Buchmiller, Marc F. Hult, Marc W. Sandstrom, Mary M. Chepiga, Berwyn E. Jones, Thomas R. Steinheimer, A. Douglas Druliner, Brian G. Katz, Marc A. Sylvester, David A. Eckhardt, Robert T. Kirkland, E. Michael Thurman, Thomas V. Fusillo, Kenneth A. Pearsall, E. J. Wexler. The workshop site coordinators, Barbara Howie, George B. Ozuna, and Rick T. Iwatsubo, U.S. Geological Survey, contributed significantly to the success of the workshops.

BIBLIOGRAPHY ON SAMPLING GROUND WATER FOR ORGANIC COMPOUNDS

Sampling Devices

Barcelona, M.J., Helfrich, J.A., Garske, E.E., and Gibb, J.P., 1984, A laboratory evaluation of ground water sampling mechanisms: Ground Water Monitoring Review, v. 4, no. 2, p. 32-41.

Ficken, J.H., 1988, Recent development of downhole samplers for trace organics, in Ground-water contamination: Field methods ASTM STP 963, Collins, A.G. and Johnson, A.J., eds., Philadelphia, Pa., American Society for Testing and Materials, p. 253-257.

Gillham, R.W., 1982, Syringe devices for ground-water sampling: Ground Water Monitoring Review, v. 2, no. 2, p. 36-39.

Ho, J.S.Y., 1983, Effect of sampling variables on recovery of volatile organics in water, in Journal of the American Water Works Association, v. 75, no. 11, p. 583-586.

Imbrigiotta, T.E., Gibs, J., Fusillo, T.V., Kish, G.R., and Hochreiter, J.J., Jr., 1988, Field evaluation of sampling devices for purgeable organic compounds in ground water, Collins, A.G. and Johnson, A.J., eds., in Ground-water contamination: Field methods, American Society for Testing and Materials Special Technical Publication 963, Philadelphia, Pa., American Society for Testing and Materials, p. 258-273.

Johnson, R.L., Pankow, J.F., and Cherry, J.A., 1987, Design of a ground-water sampler for collecting volatile organics and dissolved gases in small-diameter wells: Ground Water, v. 25, no. 4, p. 448-454.

Morrison, R.D., 1983, Ground water monitoring technology, procedures, equipment and applications: Prairie DuSac, Wis., Timco Manufacturing, Incorporated, 111 p.

Muska, C.F., Colven, W.P., Jones, V.D., Scogin, J.T., Looney, B.B., and Price, V., 1986, Field evaluation of ground-water sampling devices for volatile organic compounds, in Proceedings of the sixth national symposium and exposition on aquifer restoration and ground-water monitoring, National Water Well Association, Columbus, Ohio, May 19-22, 1986, p. 235-246.

Neilsen, D.M., and Yeates, G.L., 1985, A comparison of sampling mechanisms available for small-diameter ground water monitoring wells: Ground Water Monitoring Review, v. 5, no. 2, p. 83-99.

Pankow, J.F., Isabelle, L.M., Hewetson, J.P., and Cherry, J.A., 1984, A syringe and cartridge method for down-hole sampling for trace organic compounds in ground water: Ground Water, v. 22, no. 3, p. 330-339.

_____ 1985, A tube and cartridge method for down-hole sampling for trace organics in ground water: Ground Water, v. 23, p. 775.

Pearsall, K.A., and Eckhardt, D.A., 1987, Effects of selected sampling equipment and procedures on the concentrations of trichloroethylene and related compounds in ground water samples: Ground Water Monitoring Review, v. 7, no. 2, p. 64-73.

Pickens, J.F., Cherry, J.A., Coupland, R. M., Grisak, G. E., Merritt, W. F., and Risto, B.A., 1981, A multilevel device for ground-water sampling: Ground Water Monitoring Review, v. 1, no. 1, p. 48-51.

Shalla, R., Myers, D.A., Simmons, M.A., Thomas, J.M., and Toste, A.P., 1988, The sensitivity of four monitoring well sampling systems to low concentrations of three volatile organics: Ground Water Monitoring Review, v. 8, no. 3, p. 90-96.

Tomson, M.B., Hutchins, S., King, J.M., and Ward, C.H., 1980, A nitrogen-powered continuous delivery, all-glass-Teflon pumping system for ground-water sampling from below 10 meters: Ground Water, v. 18, no. 5, p. 444-446.

Torstensson, B.A., 1984, A new system for ground-water monitoring: Ground Water Monitoring Review, v. 4, no. 4, p. 131-138.

Unwin, J.P., 1984, A laboratory study of four methods of sampling ground water for volatile organics: National Council of the Paper Industry for Stream and Air Improvement Technical Bulletin No. 441, New York, 24 p.

Voorhees, K.J., Hickey, J.C., and Klusman, R.W., 1984, Analysis of ground water contamination by a new surface static trapping/mass spectrophotometry technique: Analytical Chemistry, v. 56, no. 13, p. 2602-2604.

Ground-Water-Sampling Techniques

Barcelona, M.J., Gibb, J.P., Helfrich, J.A., and Garske, E.E., 1985, Practical guide for ground-water sampling: Illinois State Water Survey Contract Report 374, Champaign, Ill., 94 p.

Classen, H.C., 1982, Guidelines and techniques for obtaining water samples that accurately represent the water chemistry of an aquifer: U.S. Geological Survey Open-File Report 82-1024, 49 p.

Driscoll, F.G., ed., 1986, Ground water and wells: St. Paul, Minn., Johnson Division, 1089 p.

Dunlap, W.J., McNabb, J.F., Scalf, M.R., and Cosby, R.L., 1977, Sampling for organic chemicals and microorganisms in the subsurface: U.S. Environmental Protection Agency, EPA-600/2-77-176, 26 p.

Gillham, R.W., Robin, M.J.L., Barker, J.F., and Cherry, J.A., 1983, Groundwater monitoring and sample bias: American Petroleum Institute Publication 4367, Washington, D.C., 206 p.

Kratochvil, B., Wallace, D., and Taylor, J.K., 1984, Sampling for chemical analysis: Analytical Chemistry, v. 56, no. 5, p. 113R-129R.

Pennino, J.D., 1988, There's no such thing as a representative ground-water sample: Ground Water Monitoring Review, v. 8, no. 3, p. 4-9.

Pettyjohn, W.A., Dunlap, W.J., Cosby, Roger, and Keeley, J.W., 1981, Sampling ground water for organic contaminants: Ground Water, v. 19, no. 2, p. 180-189.

Popkin, B.P., 1983, Guidelines for ground-water quality assessments for hazardous waste facilities: Ground Water Monitoring Review, v. 3, no. 2, p. 65-70.

Rickert, D.A., 1985, Guidelines on sampling ground water for determination of organic compounds--with comments on analytical protocols: U.S. Geological Survey Quality of Water Branch Technical Memorandum No. 85.09, April 22, 1985, 29 p.

Scalf, M.R., McNabb, J.F., Dunlap, W.J., Cosby, R.L., and Fryberger, J.S., 1981, Manual of ground-water quality sampling procedures: U.S. Environmental Protection Agency, EPA-600/2-81-160, 93 p.

Schmidt, K.D., 1982, How representative are water samples collected from wells, in Proceedings of the second national symposium on aquifer Restoration and Ground Water Monitoring, National Water Well Association, Columbus, Ohio, May 26-28, 1982, p. 117-128.

Seanor, A.M., and Brannaka, L.K., 1981, Influence of sampling techniques on organic water quality analyses, in Proceedings of the national conference on management of uncontrolled hazardous waste sites, Silver Springs, Md., Hazardous Materials Control Research Institute, p. 143-148.

Sgambat, J.P., and Stedinger, J.R., 1981, Confidence in ground-water monitoring: Ground Water Monitoring Review, v. 1, no. 1, p. 62-69.

U.S. Environmental Protection Agency, 1982, Handbook for sampling and sample preservation of water and wastewater: Cincinnati, Ohio, U.S. Environmental Protection Agency, 402 p.

U.S. Environmental Protection Agency, 1986, RCRA ground-water monitoring technical enforcement guidance document: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, OSWER-9950.1, Cincinnati, Ohio, 324 p.

Wilson, L.G., Dworkin, J.M., and Holden, P.W., 1984, Development of a primer on well water sampling for volatile organic substances: University of Arizona Water Resources Research Center Research Project Technical Completion Report G828-24, NTIS PB85-230043, 44 p.

Wood, W.W., 1976, Guidelines for collection and field analysis of ground-water samples for selected unstable constituents: U.S. Geological Survey Techniques of Water-Resources Investigations, book 1, chap. D2, 24 p.

Analysis of Organic Vapor(s) in Soil

Barber, A.J., and Braids, O.C., 1982, Application of a portable organic vapor analyzer in ground-water contamination investigations, in Proceedings of the second national symposium on aquifer restoration and ground-water monitoring, National Water Well Association, Columbus, Ohio, May 26-28, 1982, p. 129-132.

Barsky, J.B., Que Hee, S.S., and Clark, C.S., 1985, An evaluation of the response of some portable, direct-reading 10.2 eV and 11.8 eV photo-ionization detectors, and a flame ionization gas chromatograph for organic vapors in high humidity atmospheres: American Industrial Hygiene Association Journal, v. 46, no. 1, p. 9-14.

Clay, P.F., and Spittler, T.M., 1982, The use of portable instruments in hazardous waste site characterization, in Proceedings of the national conference on management of uncontrolled hazardous waste sites, Silver Spring, Md., Hazardous Materials Control Research Institute, November 29-December 1, 1982, p. 40-44.

Kerfoot, H.B., 1987, Soil-gas measurement for detection of ground-water contamination by volatile organic compounds: Environmental Science and Technology, v. 21, no. 10, p. 1022-1024.

Petros, J.K., and Beckett, J.W., 1984, Use of a portable vapor analyzer in ground-water contamination studies: Journal of Testing and Evaluation, v. 12, no. 4, p. 251-253.

Marrin, D.L., and Thompson, G.M., 1987, Gaseous behavior of TCE overlying a contaminated aquifer: Ground Water, v. 25, no. 1, p. 21-27.

Spittler, T.M., Clifford, W.S., and Fitch, L.G., 1985, A new method for detection of organic vapors in the vadose zone, in Proceedings of the American Water Works Association conference, Denver, Colo., November 19-21, 1985, p. 236-246.

Thompson, G.L., and Marrin, D.L., 1987, Soil gas contaminant investigations: A dynamic approach: Ground Water Monitoring Review, v. 7, no. 3, p. 88-93.

Wood, A.L., Wilson, J.T., Cosby, R.L., Hornsby, A.G., and Baskin, L.B., 1981, Apparatus and procedure for sampling soil profiles for volatile organic compounds: Soil Science Society of America Journal, v. 45, no. 2, p. 442-444.

Effects of Materials on Sorption and Desorption

Barcelona, M.J., Gibb, J.P., and Miller, R.A., 1983, A guide to the selection of materials for monitoring well construction and ground-water sampling: Illinois State Water Survey Contract Report 327, Champaign, Ill., 78 p.

Barcelona, M.J., Helfrich, J.A., and Garske, E.E., 1985, Sampling tube effects on ground-water samples: Analytical Chemistry, v. 57, no. 2, p. 460-464.

Barcelona, M.J., and Helfrich, J.A., 1986, Well construction and purging effects on ground-water samples: Environmental Science and Technology, v. 20, no. 11, p. 1179-1184.

Cowgill, U.M., 1988, The chemical composition of leachate from a two-week dwell-time study of PVC well casing and a three-week dwell-time study of fiberglass reinforced epoxy well casing, in Ground-water contamination: Field methods, American Society for Testing and Materials Special Technical Publication 963, Collins, A.G., and Johnson, A.J., eds., Philadelphia, Pa., American Society for Testing and Materials, p. 172-184.

Curran, C.M., and Tomson, M.B., 1983, Leaching of trace organics into water from five common plastics: Ground Water Monitoring Review, v. 3, no. 3, p. 68-71.

Gillham, R.W., and O'Hannesin, S.F., 1990, Sorption of aromatic hydrocarbons by materials used in construction of ground-water sampling wells, in Proceedings of symposium on standards development for ground water and vadose zone monitoring investigations, Albuquerque, N. Mex., Special Technical Publication 1053, American Society for Testing and Materials, January 27-29, 1988, p. 108-124.

Holm, T.R., George, G.K., and Barcelona, M.J., 1988, Oxygen transfer through flexible tubing and its effects on ground water sampling results: Ground Water Monitoring Review, v. 8, no. 3, p. 83-89.

Junk, G.A., Svec, H.J., Vick, R.D., and Avery, M., 1974, Contamination of water by synthetic polymer tubes: Environmental Science and Technology, v. 8, no. 11, p. 1100-1106.

Miller, G.D., 1982, Uptake and release of lead, chromium and trace level volatile organics exposed to synthetic well casings, in Proceedings of the second national symposium on aquifer protection and ground water monitoring, National Water Well Association, Columbus, Ohio, May 26-28, 1982, p. 236-245.

Reynolds, G.W., and Gillham, R.W., 1986, Absorption of halogenated organic compounds by polymer materials commonly used in ground-water monitors, in Proceedings of the second Canadian-American conference on hydrogeology, Banff, Alberta, p. 125-132.

Sara, M.N., 1986, A review of materials used in monitoring and monitoring well construction, in Proceedings of the sixth national symposium and exposition on aquifer restoration and ground-water monitoring, National Water Well Association, Columbus, Ohio, p. 330-337.

Sosebee, J.B., Geiszler, P.C., Winegardner, D.L., and Fisher, C.R., 1983, Contamination of groundwater samples with polyvinyl chloride adhesives and polyvinyl chloride primer from monitoring wells, in Conway, R.A., and Gulledge, W.P., eds., Hazardous and industrial solid waste testing: American Society for Testing and Materials Special Technical Publication 805, p. 38-50.

Well Drilling and Installation

Brobst, R.B., and Buszka, P.M., 1986, The effect of three drilling fluids on ground water sample chemistry: Ground Water Monitoring Review, v. 6, no. 1, p. 62-70.

Dunbar, D., Tuchfeld, H., Siegel, R., and Sterbentz, R., 1985, Ground water quality anomalies encountered during well construction, sampling, and analysis in the environs of a hazardous waste management facility: Ground Water Monitoring Review, v. 5, no. 3, p. 70-74.

Keely, J.F., and Boateng, Kwasi, 1987, Monitoring well installation, purging, and sampling techniques--Part 1: Conceptualizations: Ground Water, v. 25, no. 3, p. 300-313.

_____ 1987, Monitoring well installation, purging and sampling techniques--Part 2: Case histories: Ground Water, v. 25, no. 4, p. 427-439.

Luhdorff, E.E., Jr., and Scalmanini, J.C., 1982, Selection of drilling method, well design and sampling equipment for wells to monitor organic contamination, in Proceedings of the second national symposium on aquifer restoration and ground water monitoring, National Water Well Association, Columbus, Ohio, May 26-28, 1982, p. 359-365.

Degradation of Organic Compounds

Parsons, F., Wood, P.R., and DeMarco, J., 1984, Transformations of tetrachloroethene and trichloroethene in microcosms and ground water: Journal American Water Works Association, v. 76, no. 2, p. 56-59.

Smith, L.R., and Dragun, J., 1984, Degradation of volatile chlorinated aliphatic priority pollutants in ground water: Environment International, v. 10, no. 4, p. 291-298.

Vogel, T.M., and McCarty, P.L., 1987, Abiotic and biotic transformations of 1,1,1-trichloroethane under methanogenic conditions: Environmental Science and Technology, v. 21, no. 12, p. 1208-1213.

Well Purging

Barber, C., and Davis, G.B., 1987, Representative sampling of ground water from short-screened boreholes: Ground Water, v. 25, no. 5, p. 581-587.

Barber, C., and Davis, G.B., 1985, Groundwater quality monitoring: Representative sampling from boreholes to determine variations in quality with depth and time, in Proceedings of the International Association for Hydraulic Research, 21st Congress, Melbourne, Australia, August 19-23, 1985, p. 175-179.

Garske, E.E., and Schock, M.R., 1986, An inexpensive flow-through cell and measurement system for monitoring selected chemical parameters in ground water: Ground Water Monitoring Review, v. 6, no. 3, p. 79-84.

Gillham, R.W., Robin, M.J.L., Barker, J.F., and Cherry, J.A., 1985, Field evaluation of well flushing procedures, American Petroleum Institute Publication No. 4405, Washington, D.C., American Petroleum Institute, 109 p.

Herzog, B.L., Chou, S.-F.J., Valkenburg, J.R., and Griffin, R.A., 1988, Changes in volatile organic chemical concentrations after purging slowly recovering wells: Ground Water Monitoring Review, v. 8, no. 4, p. 93-99.

Keith, S.J., Wilson, L.G., Fitch, H.R., and Esposito, D.M., 1983, Sources of spatial-temporal variability in ground-water quality data and methods of control: Ground Water Monitoring Review, v. 3, no. 2, p. 21-32.

McAlary, T.A., and Barker, J.F., 1987, Volatilization losses of organics during ground water sampling from low permeability materials: Ground Water Monitoring Review, v. 7, no. 4, p. 63-68.

Palmer, C.D., Keeley, J.F., and Fish, W., 1987, Potential for solute retardation on monitoring well sand packs and its effect on purging requirements for ground-water sampling: Ground Water Monitoring Review, v. 7, no. 2, p. 40-47.

Robin, M.J.L., and Gillham, R.W., 1987, Field evaluation of well purging procedures: Ground Water Monitoring Review, v. 7, no. 4, p. 85-93.

Schuller, R.M., Gibb, J.P., and Griffin, R.A., 1981, Recommended sampling procedures for monitoring wells: Ground Water Monitoring Review, v. 1, no. 1, p. 42-46.

Unwin, J.P., 1988, Investigations of techniques for purging ground-water monitoring wells and sampling ground water for volatile organic compounds, in Ground-water contamination: Field methods, American Society for Testing and Materials Special Technical Publication 963, Collins, A.G. and Johnson, A.J., eds.: Philadelphia, Pa., American Society for Testing and Materials, p. 240-252.

Wilson, L.C., and Rouse, J.V., 1983, Variations in water quality during initial pumping of monitoring wells: Ground Water Monitoring Review, v. 3, no. 1, p. 103-109.

Safety

American Conference of Governmental Industrial Hygienists, Inc., 1986, TLVs threshold limit values and biological exposure indices for 1986-1987, Cincinnati, Ohio, American Conference of Governmental Industrial Hygienists, Inc., 111 p.

American National Standards Institute, 1982, American National Standard practices for respiratory protection: ANSI Z88.2-1980, New York, American National Standards Institute, 38 p.

National Institute for Occupational Safety and Health, 1985, National Institute for Occupational Safety and Health certified equipment list as of October 1, 1985: National Institute for Occupational Safety and Health, Department of Health and Human Services, National Institute for Occupational Safety and Health Publication Number 86-101, 3 chapters, various pagination.

Schwape, A.D., Costas, P.P., Jackson, J.O., Weitzman, D.J., 1983, Guidelines for the selection of chemical protective clothing: Cincinnati, Ohio, American Conference of Governmental Industrial Hygienists, Inc., 7 chapters, various pagination.

Tidball, R.R., 1984, Field-safety guidelines for the U.S. Geological Survey, Central Region: U.S. Geological Survey, Geologic Division, Central Region, Committee on Safety memorandum, 56 p.

U.S. Coast Guard, 1984, Chemical hazard response system manual (CHRIS), volume II, 7 chapters, various pagination.

U.S. Code of Federal Regulations, Title 29, Part 1910.120, July 1, 1987, Hazardous waste operations and emergency response, p. 340-361.

U.S. Code of Federal Regulations, Title 29, Part 1910.132, July 1, 1987, subpart I--Personal protective equipment, p. 362.

U.S. Department of Health and Human Services, 1985, Occupational safety and health guidance manual for hazardous waste site activities: Publication No. 85-115, October 1985, 12 chapters, various pagination.

_____ 1985, National Institute for Occupational Safety and Health pocket guide to chemical hazards: Washington, D.C., Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, 240 p.

_____ 1987, Organic solvent neurotoxicity: National Institute for Occupational Safety and Health current intelligence bulletin 48: Washington, D.C., Department of Health and Human Services, National Institute for Occupational Safety and Health Publication No. 87-104, 39 p.

U.S. Environmental Protection Agency, undated, Hazardous materials incident response operations: Washington, D.C., Office of Emergency and Remedial Response, Hazardous Response-Support Division, Environmental Response Team. Unpublished student manual, course no. 165.5, 7 sections.

_____ 1984, Standard operating safety guides: Washington, D.C., Environmental Response Branch, Hazardous Response Support Division, Office of Emergency and Remedial Response, 9 parts, various pagination.

U.S. Geological Survey, 1986, Safety and occupational health: Survey safety handbook (445-1-H): U.S. Geological Survey, Administrative Division, 12 chapters, various pagination.

Well-Network Design

Davis, J.C., 1986, Statistics and data analysis in geology (2nd ed.): New York, John Wiley, 646 p.

Duncan, D.W., and Oshima, R.J., 1986, 1,2-Dibromoethane (EDB) in two soil profiles, in Evaluation of pesticides in ground water: American Chemical Society, Symposium Series 315, Washington, D.C., American Chemical Society, p. 282-293.

Florida Pesticide Review Council, 1987, Pesticide assessment procedure: Florida Department of Agriculture and Consumer Services, 30 p.

Franks, B.J., ed., 1982, Principal aquifers in Florida: U.S. Geological Survey Water-Resources Investigations Open-File Report 82-255, 13 p.

Gilbert, R.O., 1987, Statistical methods for environmental pollution monitoring: New York, Van Nostrand Reinhold Company, 320 p.

Leach, S.D., 1983, Source, use, and disposition of water in Florida, 1980: U.S. Geological Survey Water-Resources Investigation 82-4090, 377 p.

McGuinness, C.L., 1963, The role of ground water in the national water situation: U.S. Geological Survey Water-Supply Paper 1800, 1,121 p.

Miller, J.A., 1986, Hydrogeologic framework of the Floridan aquifer system in Florida and in parts of Georgia, Alabama, and South Carolina: U.S. Geological Survey Professional Paper 1403-B, 91 p.

Rao, P.S.C., Hornsby, A.G., and Jessup, R.E., 1985, Indices for ranking the potential for pesticide contamination of groundwater, in Proceedings of the Soil and Crop Science Society of Florida, v. 44, p. 1-8.

Shankland, D.L., 1985, Environmental toxicants and public risk in Florida: Proceedings of the Soil and Crop Science Society of Florida, v. 44, p. 14-17.

Solley, W.B., Chase, E.B., and Mann, W.B., IV, 1983, Estimated use of water in the United States in 1980: U.S. Geological Survey Circular 1001, 56 p.

Sprinkle, C.L., 1989, Geochemistry of the Floridan aquifer system in Florida and parts of Georgia, South Carolina, and Alabama: U.S. Geological Survey Professional Paper 1403-I, p. 105.

U.S. Environmental Protection Agency, 1987, Health advisories for 16 pesticides: National Technical Information Service, PB87-200176, Springfield, Va., p. 137-155.

Weintraub, R.A., Jex, G.W., and Moye, H.A., 1986, Chemical and microbial degradation of 1,2-dibromoethane (EDB) in Florida ground water, soil, and sludge, in Evaluation of pesticides in ground water: American Chemical Society Symposium Series 315, Washington, D.C., p. 294-310.

Analytical Methods for Organic Compounds

Bagnati, R., Benfenati, E., Davoli, R., 1988, Screening of 21 pesticides in water by a single extraction with C-18 silica bonded phase columns and HRGC-MS, Chemosphere, v. 17, p. 59-65.

Beggs, D.P., 1980, GC/MS analysis of volatile organic compounds in water: American Laboratory, July 1980, p. 81-87.

Borman, S.A., 1983, New gas chromatographic detectors: Analytical Chemistry, v. 55, p. 726A-730A.

Buffington, R., Wilson, M.K., 1987, Detectors for gas chromatography--A practical primer: Avondale, Pa., Hewlett-Packard Company, 106 p.

Chau, A.S.Y., and Afgan, B.K., eds., 1982, Analysis of pesticides in water, volume I: Significance, principles, techniques, and chemistry of pesticides: Boca Raton, Fla., CRC Press, Inc., 202 p.

Chau, A.S.Y., and Afgan, B.K., eds., 1982, Analysis of pesticides in water, volume II: Chlorine- and phosphorus-containing pesticides: Boca Raton, Fla., CRC Press, Inc., 238 p.

Chau, A.S.Y., and Afgan, B.K., eds., 1982, Analysis of pesticides in water, volume III: Nitrogen-containing pesticides: Boca Raton, Fla., CRC Press, Inc., 248 p.

Diagnault, S.A., Noot, D.K., Williams, D.T., Huck, P.M., 1988, A review of the use of XAD resins to concentrate organic comounds in water: Water Research, v. 22, p. 803-813.

Giger, W., Schaffner, C., 1978, Determination of PAH in the environment by capillary glass chromatograph: Analytical Chemistry, v. 50, p. 243-249.

Hertz, H.S., May, W.E., Wise, S.A., and Chesler, S.N., 1978, Trace organic analysis: Analytical Chemistry, v. 50, p. 429A-436A.

Hill, K.M., Hollowell, R.K., and Dal Cortivo, L.A., 1984, Determination of n-Methylcarbamate pesticides in well water by LC with post-column fluorescence derivitization: Analytical Chemistry, v. 565, p. 2465-2468.

Keith, L.H., 1977, Identification and analysis of organic pollutants in water: Ann Arbor, Mich., Ann Arbor Science Publishers, 718 p.

_____ 1981, Advances in the identification and analysis of organic pollutants in water, v. 1: Ann Arbor, Mich., Ann Arbor Science, 479 p.

_____ 1981, Advances in the identification and analysis of organic pollutants in water, v. 2: Ann Arbor, Mich., Ann Arbor Science, 1170 p.

_____ 1983, Principles of environmental analysis: Analytical Chemistry, v. 55, p. 2210-2218.

Kramer, J.W., Baker, D.B., 1985, An analytical method and quality control program for studies of currently used pesticides in surface waters, in Taylor, J.K., Stanley, T.W., eds., Quality assurance for environmental measurements, Philadelphia, Pa.: American Society for Testing and Materials Special Technical Publication 867, American Society for Testing and Materials, p. 116-132.

Krause, R.T., 1988, HPLC determination of aryl n-Methylcarbamate residues using post-column hydrolysis electrochemical detection: Journal of Chromatography, v. 442, p. 333-343.

Longbottom, J.E., and Lichtenberg, J.J., eds., 1982, Test methods--Methods for organic chemical analysis of municipal and industrial wastewater: U.S. Environmental Protection Agency Report No. 600/4-82-057, July 1982, p. 178.

Lopez-Avila, V., Hirata, P., Kraska, S., Flanagan, M., Taylor, J.H., Hern, S.C., 1985, Determination of atrazine, lindane, pentachlorophenol, and diazinon in water and soil by isotope dilution GC/MS: Analytical Chemistry, v. 57, p. 2797-2801.

Minear, R.A., and Keith, L.H., 1984, Water analysis, volume 3, organic species: Orlando, Fla., Academic Press, Inc., p. 456.

Nubbe, M.E., Dean Adams, V., Watts, R.J., Robert-Clark, Y.S., 1988, Organics: Journal of the Water Pollution Control Federation, v. 60, p. 773-796.

Ottmers, D.M., Jr., Jones, D.C., Keith, L.H., and Hall, R.C., 1979, Instruments for environmental monitoring: Chemical engineering/ deskbook issue, October 1979, v. 13, p. 85-96.

Ozretich, R.J., Schroeder, W.P., 1986, Determination of selected neutral priority organic pollutants in marine sediment, tissue and reference materials utilizing bonded-phase sorbents: Analytical Chemistry, v. 58, p. 2041-2048.

Schnute, W.C., and Smith, D.E., 1980, GC/MS in environmental analysis: Woburn, Mass., American Laboratory, May 1980, p. 87-95.

Sporstol, S., Gjos, N., Lichtenhaler, R.G., Gustavsen, K.O., Urdal, K., Oreld, F., Skel, J., 1983, Source identification of aromatic hydrocarbons in sediments using GC/MS: Environmental Science and Technology, v. 17, p. 282-286.

Uden, P.C., 1987, Detection in quantitative gas chromatography, in Katz, E., ed., Quantitative analysis using chromatographic techniques: New York, John Wiley, p. 99-155.

Wells, D.C., 1988, Extraction, clean-up, and group separation techniques in organochlorine trace analysis: Pure and Applied Chemistry, v. 60, p. 1437-1448.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., 1987, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A3, 173 p.

Transport of Organic Compounds

Cheremisinoff, P.N., Gigliello, K.A., and O'Neill, T.K., 1984, Groundwater-leachate modeling/monitoring/sampling: Lancaster, Pa., Technomic Publishing Company, 146 p.

Donigian, A.S., Jr., Yo, T.Y.R., and Shanahan, E.W., 1984, Rapid assessment of potential ground-water contamination under emergency response conditions: U.S. Environmental Protection Agency Publication EPA-600/8-83-030, 147 p.

Freeze, R.A., and Witherspoon, P.A., 1966, Theoretical analysis of regional groundwater flow: 1. Analytical and numerical solutions to the mathematical model: Water Resources Research, v. 2, no. 4, p. 641-656.

_____ 1967, Theoretical analysis of regional groundwater flow: 2. Effect of water-table configuration and subsurface permeability variation: Water Resources Research, v. 3, no. 2, p. 623-634.

_____ 1968, Theoretical analysis of regional ground water flow: 3. Quantitative interpretations: Water Resources Research, v. 4, no. 3, p. 581-590.

Toth, J., 1963, A theoretical analysis of groundwater flow in small drainage basins: Journal of Geophysical Research, v. 68, no. 16, p. 4795-4812.

Winter, T.C., 1978, Numerical simulation of steady state three-dimensional groundwater flow near lakes: Water Resources Research, v. 14, no. 2, p. 245-254.

Miscellaneous References

Biggar, J.W., Sieber, J.N., 1987, Fate of pesticides in the environment: Oakland, Ca, University of California, 157 p.

Connell, D.W., and Miller, G.J., 1984, Chemistry and ecotoxicology of pollution: New York, John Wiley, 444 p.

DiPerna, P., 1984, Leukemia strikes a small town: New York Times Magazine, December 2, 1984, p. 100-107.

Ferrara, R.A., Gray, W.G., and Pinder, G.F., 1984, Groundwater contamination from hazardous wastes: Englewood Cliffs, N.J., Prentice-Hall, 163 p.

Friedman, L.C., Schroeder, L.J., and Brooks, M.G., 1986, Recovery of several volatile organic compounds from simulated water samples: Effect of transport and storage: Environmental Science and Technology, v. 20, no. 8, p. 826-829.

Harkin, J.M., Jones, F.A., Fathulla, R.N., Dzantor, E.K., Kroll, D.G., 1986, Fate of aldicarb in Wisconsin ground water, in Garner, W. Y., Honeycutt, R.C., and Nigg, H.N., eds.: Evaluation of pesticides in ground water, Washington, D.C., American Chemcial Society, p. 219-255.

Lyman, W.J., Reehl, W.F., Rosenblatt, D.H., 1982, Handbook of chemical property estimation methods: New York, McGraw-Hill, 700 p.

Mabey, W.R., Smith, J.H., Podoll, R.T., Johnson, H.L., Mill, T., Chou, T.-W., Gates, J., Waight-Partridge, I., Jaber, H., and Vandenberg, D., 1982, Aquatic fate process data for organic priority pollutants: U.S. Environmental Protection Agency Report No. 440/4-81-014, December 1982, 434 p.

Moore, J.W., and Ramamoorthy, S., 1984, Organic chemicals in natural water: Applied Monitoring and Impact Assessment: New York, Springer-Verlag, 289 p.

National Research Council, 1984, Groundwater contamination: Washington, D.C., National Academy Press, 179 p.

Neely, W.B., and Blau G.E., 1985, Environmental exposure from chemicals, Volume I: Boca Raton, Fla., CRC Press, 245 p.

Ogawa, I., Junk, G.A., and Svec, H.J., 1981, Degradation of aromatic compounds in groundwater and methods of sample preservation: Atlanta, v. 28, p. 725-729.

Pankow, J.F., 1986, Magnitude of artifacts caused by bubbles and headspace in the determination of volatile compounds in water: Analytical Chemistry, v. 58, no. 8, p. 1822-1826.

Rostad, C.E., Pereira, W.E., and Ratcliff, S.M., 1984, Bonded-phase extraction column isolation of organic compounds in ground water at a hazardous waste site: Analytical Chemistry, v. 56, no. 14, p. 2856-2860.

Schnitzer, M., and Khan, S.U., 1972, Humic substances in the environment: New York, Marcel Dekker, 327 p.

_____ 1978, Soil organic matter: Amsterdam, Elsevier, 319 p.

Smith, J.A., Witkowski, P.J., and Fusillo, T.V., 1987, Manmade organic compounds in the surface waters of the United States: A review of current understanding: U.S. Geological Survey Circular 1007, 92 p.

Thurman, E.M., 1985, Organic geochemistry of natural waters: Dordrecht, the Netherlands, Martinus Nijhoff-Dr., N. Junk Publishers, 497 p.

Tinsley, I.J., 1979, Chemical concepts in pollutant behavior: New York, Wiley-Interscience, 265 p.

U.S. Environmental Protection Agency, 1985, Protection from ground-water contamination: EPA/625/4-85/016, 182 p.

Verscheueren, K., 1983, Handbook of environmental data on organic chemicals, 2nd ed., New York, Van Nostrand Reinhold, 1,310 p.

Ward, C.H., Giger, W., and McCarty, P.L., eds., 1985, Ground water quality: New York, John Wiley, 547 p.

Witowski, P.L., Smith, J.A., Fusillo, T.V., and Chiou, C.T., 1987, A review of surface-water sediment fractions and their interactions with persistent manmade organic compounds: U.S. Geological Survey Circular 993, 39 p.

Appendix A: Agenda for workshop "Sampling ground water for organic compounds," held in Trenton, New Jersey, May 11-15, 1987

Workshop Agenda

Monday

Introduction
- Objectives of workshop

Physical and chemical characteristics of synthetic organic compounds
- Characteristics and properties
- Relationship of compound characteristics to analytical methodologies
- Behavior and fate in ground water

Break
- Physical processes of plume formation in the unsaturated and saturated zones
- Advection and dispersion of plumes

Lunch

Factors affecting sampling design
- Overview
- Hydrogeologic effects

Break
- Network design
- Panel discussion

Adjourn

Tuesday

Drilling and installation options
- Drilling techniques
- Well construction
- Clean well procedures
- Development

Break
- Effects of materials of construction of existing and new wells on water quality
- Discussion

Lunch

Sampling equipment
- Commercial devices
- State-of-the-art devices
- Principles of operation
- Cost

Comparison of sampling devices
- Purgeable compounds
- Other constituents

Break

Safety
- U.S. Geological Survey, Water Resources Division Protocols
- U.S. Environmental Agency Protocols
- Drilling
- Sampling

Adjourn

Equipment exhibit/social hour
   Manufacturers' representatives

Wednesday

Field demonstrations (concurrent sessions)
   Determination of stability
   Demonstration of sampling devices
   Sampling techniques
   Unsaturated-zone vapor sampling
   Unsaturated-zone vapor analysis
   Field-safety equipment

Thursday

Comparison of analytical techniques
   Isolation and concentration
   Compound detection
Break/Discussion
   Gas Chromatography/Flame Ionization Detector scan
Evaluation of analytical data
   Accuracy
Discussion
Lunch
   Precision
   Significant differences
Discussion
Project management
   Work plan
   Quality assurance/quality control requirements
   Sampling and waste disposal
Break
Group discussion of sampling problems
   BYOSP (Bring your own sampling problem)
   Successes and failures
Adjourn

Friday

Field demonstration data
Discussion
Workshop critique
   Oral
   Written
Adjourn

Appendix B: Agenda for workshop "Sampling ground water for organic compounds," held in Miami, Florida, November 16-20, 1987

Workshop Agenda

Monday

Workshop objectives
Physical and chemical characteristics of synthetic organic compounds
Behavior and fate in ground water
Plumes (formation, advection, dispersion)
Ground-water-flow-system factors that affect sampling
Network-design factors that affect sampling
Safety

Tuesday

Sampling equipment
Site reconnaisance
Site introduction
Field demonstration

Wednesday

Sampler comparison
Effects of materials on sampling
Analytical methods
Quality assurance/quality control and evaluation of analytical data

Thursday

Pesticides in ground water
Discussion of sampling problems
Field-data results
Critiques and wrap-up

Appendix C: Agenda for workshop "Sampling ground water for organic compounds," held in San Antonio, Texas, February 29-March 4, 1988

Workshop Agenda

Monday

Welcome
Workshop objectives
Physical and chemical characteristics of synthetic organic compounds
Break
Behavior and fate of organic compounds in ground water
Basic principles of solute transport

Tuesday

Plume mechanics, well hydraulics, and the effects of wells on water samples
Break
Drilling, casing, and decontamination of monitoring wells
Safety
Sampling equipment
Break
Field screening for volatile organic compounds, soil gas and head-space analysis
Design and execution of an Installation Restoration Program Study
Introduction to the site

Wednesday

Field demonstration: sampling and samplers, field gas chromatograph, soil-gas analysis
Sampler comparison
Effects of materials on water quality
Quality assurance/quality control
Open house for manufacturers' representatives

Thursday

Analytical methods for organic compounds
Pesticide sampling and field screening
Discussion of field-sampling results
Sampling problems discussion
Critiques and wrap-up

Appendix D: Agenda for workshop "Sampling ground water for organic compounds," held in Sacramento, California, December 12-16, 1988

Workshop Agenda

Monday

Welcome, introductions, preview of the week,
  and workshop objectives
Physical and chemical
  characterisitics of synthetic
  organic compounds
Break
Behavior and fate of organic
  compounds in ground water
Lunch
Basic principles of solute transport
Break
Plume mechanics, well hydraulics,
  and the effects of wells on water samples
Sampling the aquifer

Tuesday

Isotopes in ground water
Safety precautions and health
Break
Types of sampling equipment
Lunch
Field screening for volatile
  organic compounds, soil gas,
  and head-space analysis
Enzyme-based field screening
  for pesticides
Break
Introduction to the field site;
  travel plans and agenda for
  tomorrow morning

Wednesday

At field site: sampling procedures and demonstrations of
  field gas chromatograph, enzyme-based methods, field equipment
Clean-up, lunch and return to motel conference room
Comparison of sampling devices; comparison of purging criteria
Break
Effects of materials used on contamination potential in the field

Thursday

Analytical methods for organic compounds
Break

Pesticides--general chemistry, transport and fate, sampling and preservation
Quality analysis/quality control--from the field and data perspectives
Lunch
Oxidation-reduction measurements and sampling for metals in ground water
Break
Importance of microbial ecology to the study of ground water
Kodiak Island, Alaska--A case study

Friday

Discussion of class sampling results from field site
Break
Open discussion with instructors and class participants
Critique and wrap-up