FOREWORD

Environmental analysis is the fundamental technology of the whole environmental industry. It is a combination of traditional and modern chemistry techniques and civil engineering materials characterizations, mixed together with a hefty dose of legalistic regulatory jargon. The majority of the users of the information produced by environmental laboratories, and for that matter the majority of the people performing the analyses, have little or no formal training in chemistry. The writers of analytical methods in both the EPA and the *Standard Methods* manuals have sought to simplify the procedures to the greatest extent possible and present each method as a recipe, which, if followed exactly, will produce an acceptable answer. This results in situations where seemingly anomalous results cannot be explained because an in-depth chemical understanding of the test procedure is lacking.

While teaching environmental chemistry as a course to civil engineering students, I found that the most profitable approach was to present the chemical and biological background information as an adjunct to understanding the individual analytical procedures. I have always felt that a fundamental understanding of how the procedure worked led to better performance of the test by the technician. Unfortunately, the explanations for many of the tests used in environmental analysis are difficult to find, being scattered in many texts. This text is a collection of all the explanations for all the questions I have asked while working as an environmental analyst.

Another reason for writing this handbook is to gather together in one convenient place the miscellaneous facts and figures necessary in performing environmental analysis. Having this handbook nearby will be appreciated by those who, like me, keep misplacing the tables for Langelier's index and the *t*-statistic, and can't remember the COD value for KHP.

Finally, this handbook was written as a general guide to what information is important in environmental analysis and where to find it. Every year the environmental business changes with new programs, new regulations, and new methods. It's a daunting task for the newcomer to assimilate enough information to get up to speed and function, let alone appear literate.

What's new in the Fourth Edition

The Internet has become the key resource within the environmental analytical industry. The amount of information available to be down-loaded is staggering. Almost everything that has been or is being published from Federal and State government agencies is available. Simply keeping up-to-date with the major regulatory programs as they change and evolve is a fulltime job. However, because of the instant availability of information, the excuse that, "we didn't know'" is less and less tenable to clients and regulators.

With this Fourth Edition, the entire book has been revised. Section 3, Organic Parameters, has undergone a complete re-write to include detailed discussions of both Updates III and IV to SW-846, and other evolving methodologies. Other major revisions include discussions of the AFCEE QAPP version 3.0, and *Standard Methods* 20th Edition. A discussion of Natural Attenuation is added. The FIFRA program has published a consolidated methods manual which is described. The EPA has established a workgroup to prepare a biosolids analytical manual and the progress to date is reviewed. An expanded discussion of toxicity testing for both EPA and OECD is

included. Groundwater and site-remediation evaluations using the Appendix IX list of analytes are discussed in Section 4. A discussion of Water Quality Criteria is added in Section 1. The commercialized PE replacement program for the WS and WP studies is examined and contacts into NELAP are presented. Many new and revised analytcial methods have been added to the lists in Section 1.II. References to and discussion of over 30 new or revised testing manuals have been included. The Regulatory Contact directory has been up-dated to the most current information, particularly with regards to telephone numbers.

Although EPA has been debating and preparing for agency-wide implementation of Performance Based Methods Systems (PBMS) for several years, the final versions for most of the regulatory programs have not been promulgated. Even the Office of Solid Waste's RCRA program testing manual (SW-846), which is written as guidance, has yet to be implemented as PBMS. However PBMS is coming. Successful utilization of PBMS by laboratories requires operation from a broad-based analytical knowledge base. Over the years this *Handbook* has evolved as my own personal set of references into that knowledge base. My own copy is dog-eared and filled with sticky notes. I am always open to suggestions as to how I can make it more useful. If you have a question or comment, just send an e-mail to me at r-ksmith@asi-lab.com.

I thank and acknowledge the contributions and suggestions from all my friends and colleagues in the industry and my editor at Genium Publishing.

Roy-Keith Smith, PhD
May, 1999

Table of Contents

Section 2 Physical, Biological and General Chemical Parameters, *continued*

SECTION 1

Introduction to Environmental Analysis

No plant manager wakes up in the morning and on the spur of the moment decides to go down to the plant wastewater outfall, take a sample of the effluent and send it off to an environmental laboratory for testing. The testing is expensive and adds directly to the cost of manufacturing products without creating any additional value in the product. The only reason that the plant manager takes the sample is because he is directed to do so by a federal or state government regulation. The environmental industry is a regulated industry in the sense that it exists solely because it services government requirements for monitoring, remediation and pollution prevention. Persons in the industry who refuse to recognize this fundamental motivating force and fail to keep themselves informed of changes in the regulations are deluding themselves and will eventually run into the reality of what it means to be ignorant of government directives.

I. APPLICABLE FEDERAL AND STATE REGULATIONS

A. Title 40, Code of Federal Regulations: Protection of Environment

Titles in the Code of Federal Regulations (CFR) are compilations of the rules and regulations promulgated by the federal government to define, implement, and enforce the laws enacted by the Congress of the USA and signed into effect by the President. They are the ultimate authority (other than the Supreme Court) of federal requirements. Many commercial (and municipal) laboratories miss this point. It is against the Federal law of the land not to follow explicitly the methods listed in the CFR. Every laboratory should have a copy of 40 CFR on hand and a competent legal firm, which specializes in environmental issues, under retainer to interpret the laws. New editions of 40 CFR are published annually, and the most recent edition should be in the lab's collection of reference materials. 40 CFR is available on-line from the Government Printing Office, See Appendix F of this book for the address.

SECTION 2

Physical, Biological and General Chemical Parameters

I. PHYSICAL PARAMETERS

A. Solids (SM18 2540*; EPA 160)

Solids (also called residues) are an important characterization of drinking and wastewater, and one or another of the tests are normally required in all DMRs of NPDES permits. Conceptually simple tests, in practice the determinations can be tedious when attempting to dry the solid to a constant weight, the biggest problem stemming from bound water. Various classes of bound water are associated with solids, the difficulty in removing them decreases as one goes down the list:

- Chemically combined water such as in calcium hydroxide
- Water of crystallization, water occupying fixed positions in the crystal structure
- Water of hydration, water hydrogen bonded onto the crystal structure
- Occluded water, droplets of water encased by a solid coating
- Absorbed water, water in the body of the solid, also called pore water
- Adsorbed water, water on the surface of the solid

Solids are divided into classes with the class defined by how the test is performed. The general classes are total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), total volatile solids (TVS), total volatile dissolved solids (TVDS), total volatile suspended solids (TVSS), settleable solids, and ash (fixed solids). It might be expected that total solids should equal total suspended solids plus total dissolved solids, TS = TSS + TDS, however this seldom works out in practice as the TS and TSS values are obtained from a 104 °C drying and the TDS at 180 °C. The volatile fractions are determined by the difference between the dried fraction and the ashed fraction and are often held to represent the organic part of the solid. However, loss of CO_2 from carbonates and bicarbonates and loss of volatile inorganic salts can give very misleading results. Other derivative measures, such as sludge volume index (SVI), are calculated from these fractions. The MDL of the analysis is dependent upon not only the volume or mass of the sample tested but also the minimum residual mass of the solid required. For example TS requires at least 2.5 mg residue, which, based on a 100 mL sample, gives a MDL of 25 mg/L. The MDL can be lowered by evaporating successive 100 mL portions in the same dish; however; the principle of diminishing returns quickly applies.

* The publication containing these methods can be accessed through the Tables in Section 1.II.

SECTION 3

Organic Parameters

An analytical process generally first determines what is present (qualitative analysis) and then determines how much (quantitative analysis). Most of the methods discussed in the previous section are highly specific for the target parameter and have relatively few interferences. Thus the qualitative and quantitative analyses are performed simultaneously. The analysis of organic parameters is much more complex than the determination of the inorganics. To a large part the complexity of the analysis is due to the small range of physical and chemical properties the different organic target analytes exhibit. Any procedure used for organic pollutant analysis will almost always result in determination of a large number of compounds. The qualitative aspects of the analysis become of foremost importance before the determination of how much is present. Most methods for organic analysis embody some sort of separation technique (GC or HPLC) for isolating target analytes and then characterize the isolates with a detector.

Once compounds are separated by some means it is necessary to translate the chemical information of the separation to some usable data form, generally electrical. There are many types of detection, based on a variety of physical properties of the target compounds. In general the explanation of the technique is much more involved than the hardware and software required to put the technique in practice.

1. Conductivity - Conductivity is the inverse of resistance, which is actually what is measured. A potential is applied across a flow of solvent and the decrease in resistance is measured as a positive signal. This can be directly applied to the eluting solvent in HPLC. In GC this technique is used in the Hall (Electrolytic Conductivity) Detector. A selective detector for halogenated compounds is made by mixing the carrier gas stream from the GC column with hydrogen and passing it through a 800 - 900 °C nickel tube. The halogens are reduced to hydrogen halides such as HCl and HBr. The gas flow is then bubbled into a non-conductive yet polar solvent such as propanol. The fluid stream then passes through the conductivity cell, and the decrease in resistance of the flow measured as an electrical signal. Appropriate modifications allow selective detection of nitrogen and sulfur compounds.
2. Spectroscopy - Electromagnetic radiation interacts with compounds in a number of ways. These techniques are often used both as qualitative and quantitative tools. The quantitative aspect is embodied in Lambert-Beers Law (A = abc), which states that absorption is equal to the product of the absorption coefficient (a), the pathlength of the sample (b) and the molar concentration (c) of the analyte. For most procedures this is a linear relationship for at least some range of concentration.

SECTION 4

Hazardous Waste and Remediation Analysis

I. HAZARDOUS WASTE CHARACTERIZATION

Chemical hazards are everywhere there is industry, and most chemicals present health and environmental dangers. EPA is not overly concerned with the responsible use of chemicals for manufacturing. A 55 gallon steel drum of 50% sodium cyanide in water solution is not a EPA hazard if it is intended to be used. However once the decision is made by the owner that the drum is not to be used, and he will dispose of it, then EPA becomes involved. The legislated responsibility of EPA is to oversee proper disposal of wastes to insure protection of human health and the environment.

Hazardous wastes can be identified by one of two general processes. The first is a list of specific wastes from industrial sources that are designated as hazardous. EPA has four lists that cover these classifications of wastes, the F, K, P and U lists.

Hazardous wastes in the F- series are from generic industrial sources. An example is F007 - Spent cyanide plating bath solutions from electroplating operations.

Hazardous wastes in the K-series are from specific sources. An example is K024 - Distillation bottoms from the production of phthalic anhydride from naphthalene.

Hazardous wastes from commercial chemical products, intermediates and residues are listed in the P-series (acute hazard) and U-series (general hazard). Examples are P057 - 2-Fluoro acetamide (CAS No. 640-19-7) and U202 - Saccharin and salts (CAS No. 81-07-2).

These regulations and lists are presented in 40 CFR 261 through 264. Part 261 contains Appendix VII, the basis for listing chemical wastes. In chemical terms this is a list of what hazardous compounds are contained in the waste that causes it to be the F list or the K list. Also in Part 261 is the Appendix VIII list of hazardous constituents. Appendix VIII is nothing more than the alphabetical listing of the P-series and U-series substances. A number of persons in the environmental industry are under the misconception that Appendix VIII is a list of analytical targets for laboratory testing. In reality performing an “Appendix VIII” analysis is impossible - many of the compounds (137) are either not available as standards on a routine basis or the appropriate technique for unambiguous analysis is well beyond the means of the average environmental laboratory. Examples are A2213 (CAS 30558-43-1, U394), aluminum phosphide (CAS 20859-73-8, P006), mercury fulminate (CAS 628-86-4, P065), and mitomycin C (CAS 50-07-7, U010). Instead the intention of the list is so that if the generator of the waste, through knowledge of the history and source of the waste, knows that the waste consists of one or more of the listed compounds, the waste is hazardous by definition.

On the other hand, the Appendix IX list from 40 CFR Part 264 was originally intended as an analytical list for monitoring the groundwater around hazardous waste

SECTION 5

Air Pollution and Monitoring

One of the more interesting phone calls an environmental laboratory will receive is from an existing or potential client who says, "We have an odor down here, and we need to know what it is." After an extended game of 20 questions, the Project Manager will forward the client's problem to the technical manager for air analysis and the game will be repeated. The lab's objective is to intelligently guess exactly what is causing the problem, then go to the site and take a sample for an analysis that will confirm the guess.

I. SAMPLING

The proper method of air sampling depends to a great extent on the desired target analytes, the test method chosen and the tested object. The EPA has published methods for testing outdoor ambient air, indoor air, motor vehicle exhausts, and stationary sources. The latter are point sources of atmospheric effluent for industries, most often referred to as stacks. The EPA also has methods for testing volatile emissions from painted or coated items. Some analytes can be directly quantitated in the gas phase, and transportation of the instrument to the sampling site becomes part of the preferred sampling method. However, most analytes cannot be directly measured and must be trapped on a solid adsorbent or in a liquid before transportation to the laboratory and analysis. In general the analytes directly measured in the field depend on gas phase chemistry, while the solution- or solid-trapped analytes are determined by techniques similar to those already discussed for analysis of water or solid samples.

The most complete collection of reliable air sampling and analysis methods is that published by NIOSH. The contents of the manual are presented in Section 1.II. Whereas EPA has concentrated for the most part upon development of multi-analyte sampling and analysis methods, the individual NIOSH procedures are focused upon a single specific analyte. The result is that the sampling technique is optimized for a single target analyte. Most of the NIOSH procedures will specify an absorbent media and the desorption solvent/technique for the analyte, and the results are quite reliable. However, if the target analyte is not specified, the NIOSH procedures become very tedious, as a multitude of absorbent tubes must be taken to the site for sampling

A. Filter Cassette

A common and easy form of sampling is the filter cassette. This consists of an appropriate filter of paper, polymer membrane, or glass fibers backed with a support in a holder. The filters can have a range of random pore sizes as in the glass fiber filters or be

Illustrations

Figure No. | **Illustration Titles, *continued*** | **Page No.**

Section 2 Physical, Biological and General Chemical Parameters, *continued*

Section 3. Organic Parameters

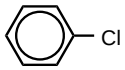
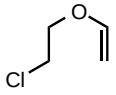
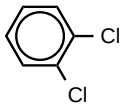
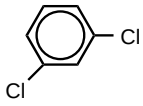
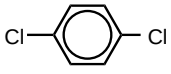
Figure No.	Illustration Titles, *continued*	Page No.

Tables

APPENDIX **A**

List of Analytes

Table A-1. Halogenated Volatile Organic Target Analytes

Target Analyte	CAS No.	Structure
Bromodichloromethane	75-27-4	$BrCl_2CH$
Bromochloromethane	74-97-5	$BrCH_2Cl$
Bromoform	75-25-2	Br_3CH
Bromomethane	74-83-9	$BrCH_3$
Carbon tetrachloride	56-23-5	CCl_4
Chlorobenzene	108-90-7	
Chloroethane	75-00-3	$ClCH_2CH_3$
2-Chloroethylvinyl ether	100-75-8	
Chloroform	67-66-3	$CHCl_3$
Chloromethane	74-87-3	CH_3Cl
Dibromomethane	74-95-3	Br_2CH_2
Dibromochloromethane	124-48-1	Br_2ClCH
1,2-Dichlorobenzene	95-50-1	
1,3-Dichlorobenzene	541-73-1	
1,4-Dichlorobenzene	106-46-7	
Dichlorodifluoromethane	75-71-8	CCl_2F_2

Continued on next page.

APPENDIX **B**

Common Acronyms

AA. atomic absorption

ATP. adenosine triphosphate

BAT. best available technology

BDL. below detection limit

BDMC. 4-bromo-3,5-dimethylphenyl -N-methylcarbamate

BFB. 4-bromofluorobenzene

BHC. 1,2,3,4,5,6-hexachlorocyclo-hexane

BN. base neutral

BNA. base neutral and acid

BOD. biochemical oxygen demand

BTEX. benzene, toluene, ethyl benzene and xylene

CBOD. carbonaceous biochemical oxygen demand

CCC. calibration check compounds

CCV. continuing calibration verification

CERCLA. Comprehensive Environmental Response, Compensation & Liability Act

CFR. Code of Federal Regulations

CLP. contract laboratory program

CNCl. cyanogen chloride

CND. 1-chloro-2,4-dinitrobenzene

CNS. central nervous system

COD. chemical oxygen demand

CTAS. cobalt thiocyanate active substances

CWA. Clean Water Act

DAD. diode array detector

DBC. dibutylchlorendate

DBUB. 4,4-dibromooctafluoro-biphenyl

DCPA. 3,5-dichlorophenylacetic acid

DDD. 2,2-bis(4-chlorophenyl)-1,1-dichloroethane

DDE. 2,2-bis(4-chlorophenyl)-1,1-dichloroethene

DDT. 2,2-bis(4-chlorophenyl)-1,1,1-trichloroethane

DER. Department of Environmental Regulation

DFTPP. decafluorotriphenylphosphine

DI. deionized

DMR. discharge monitoring report

DNA. deoxyribonucleic acid

DNPH. 2,4-dinitrophenylhydrazine

DO. dissolved oxygen

DOC. dissolved organic carbon

DOE. Department of Energy

DPD. N,N-diethylphenylene diamine

DQO. data quality objective

DRO. diesel range organics

EC. effective concentration

ECD. electron capture detector

EDTA. disodium ethylenediaminetetra-acetic acid

ELCD. electrolytic conductivity detector

EPP. electronic pressure programming

EPA. Environmental Protection Agency

EQL. estimated quantitation limit

APPENDIX **C**

Specialized Laboratory Glassware

In the environmental laboratory there are a number of very specialized pieces of glassware not found in other laboratories. They are for the most part used in the organics sample preparation area. The thick lines on the diagrams represent assembly points, which may be Teflon® lined threaded joints or ground glass joints (linear or ball design).

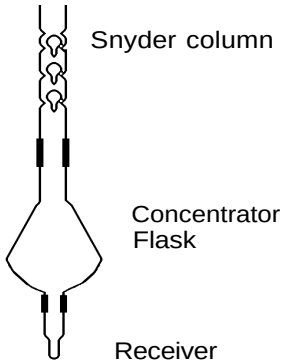


Figure C-1. Kuderna-Danish concentrator.

The Kuderna-Danish (K-D) concentrator is used to reduce the volume of organic solvent sample extracts. Boiling chips (Teflon® is prefered, but a variety of materials is used.) are placed in the tip of the receiver, the extract is added, and the apparatus is heated on a steam table. Clean solvent is added to the top of the Snyder column to wet the balls. The sample is concentrated until 3-4 mL remain in the receiver, then removed from the heat source and allowed to cool. The extract is transfered to a volumetric flask[1] for final concentration to an appropriate volume under a gentle stream of nitrogen gas. The volume graduations on the receiver are only approximate

[1] A very useful procedure is to obtain 2 mL Class A volumetric tubes with ground glass stoppers and calibrate them at the 1.000 mL level with an etch mark on the glass. The tubes hold about 4 mL of extract and are very easy to monitor as the solvent level drops to the 1 mL level during nitrogen blowdown. Internal standards can then be added and the contents of the tube shaken with the stopper in place before final transfer to an autosampler vial.

APPENDIX **D**

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I. QUALITY ASSURANCE

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Taylor, J.K., *Quality Assurance of Chemical Measurements*. Orlando Fla.: Lewis Publishers. 1987.

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APPENDIX **E**

Vendors

I. ANALYTICAL STANDARDS

NSI Environmental Solutions, P.O. Box 12313, Research Triangle Park, NC 27709. 800-234-7837

AccuStandard, Inc., 25 Science Park, Box 1, New Haven, CT 06511. 203-786-5290

Analytical Products Group, Inc., 2730 Washington Blvd., Belpre, OH 45714. 800-272-4442 (PET Program)

Ultra Scientific, 250 Smith Street, North Kingston RI 02852. 401-294-9400

SPEX CertiPrep, 203 Norcross Avenue, Metchen NJ 08840. 800-522-7739 or 908-549-7144.

Environmental Resource Associates, 5540 Marshall Street, Arvada, Colorado 80002. 800-372-0122 (PET Program)

Chem Service, 660 Tower Lane, P.O. Box 599, West Chester, PA 19381-0599. 610-692-3026

Plasma-Chem Corporation, 5142 West Hurley Pond Rd., Farmingdale, NJ 07727. 800-343-0437

American Type Culture Collection, 12301 Parklawn Dr., Rockville, MD 20852. 800-638-6597

Fisher Scientific, 2775 Pacific Drive, Norcross, GA 30091. 770-449-5050

VWR Scientific Products, P.O. Box 626, Bridgeport, NJ 08014. 800-234-5227

Protocol Analytical Supplies, Inc., 472 Lincoln Blvd., Middlesex, NJ 08846. 800-862-0080

Standard Reference Materials, National Institute of Standards and Technology, Building 202, Room 204, Gaithersburg, MD 20899. 301-975-6776

Radian International LLC, P.O. Box 201088, Austin TX 78720-1088, 1-800-848-7837

Restek Corporation, 110 Benner Cir. Bellefonte PA 16823-8812, 1-800-356-1688

Analytical Standards, Inc., P.O. Box 183, 6331 Emerson Avenue, Parkersburg, WV 26102-0183, (304) 442-4274

APPENDIX **F**

Regulatory Contact Directory

NATIONAL AND REGIONAL CONTACTS

ENVIRONMENTAL HOTLINES

Asbestos & Small Business Ombudsman Office
All except VA.....(800) 368-5888
VA only .....(703) 557-1938
TDD machine .....(703) 557-2824
Provides information to the public sector, including individual citizens and community services on the handling and abatement of asbestos in schools, the workplace and the home.

Chemical Manufacturers Association Hotlines
National.....(703) 741-5000
Non-emergency information on chemicals
Chemical Referral Center (CRC)
Chemtree Non-emergency.....(800) 262-8200
Provides Chemical Emergency Information.

CHEMTREC
National.....(800) 424-9300
Dist. of Columbia.....(202) 887-4620

Consumer Product Safety Commission Hotline
National.....(800) 638-2772

Emergency Planning and Community Right-to-Know (Title III SARA) Hotline
National .....(800) 535-0202
Virginia .....(703) 920-9877
Provides regulatory, policy and technical assistance to federal agencies, local and state governments, the public and regulated community in response to questions related to the Emergency Planning and Community Right-to-Know Act (Title III of SARA). Information on reporting of hazardous substances for community planning purposes.

EPA Hotline .....(800) 438-2474

EPA Superfund (Region II Investigative Hotline)
Restricted area codes as follows: 809, 201, 609, 908, 906, 212, 315, 516, 518, 607, 716, 718, 914.....(800) 245-2738
Enables the Superfund Civil Investigators to receive information relevant to specific Superfund Site Enforcement Investigations.

TSCA Assistance Information Services
.....(202) 554-1404
Provides technical assistance and information about the Toxic Substances Control Act (TSCA), the Asbestos School Hazard Abatement Act (ASHAA), the Asbestos Hazard Emergency Response Act (AHERA), the Asbestos School Hazard Abatement Reauthorization Act (ASHARA), the Residential Lead-based Pain Hazard Reduction Act, and the Pollution Prevention Act (PPA), and 33/50 Program.

Mercury Hotline
National.....(800) 833-3505
Provides answers to questions. No emergency Service

National Pesticides Telecommunications Network
National, incl. US, PR,
and Virgin Island.....(800) 858-7378
FAX: .....(541) 737-0761
Provides the medical, veterinary, professional communities and general public with information on: pesticides and herbicides product information, recognition and management of pesticide poisonings, toxicology and symptomatic reviews, safety information, health and environmental effects, clean-up and disposal procedures.

Alphabetical Elements List

Element[1]	Symbol	Number	Mass
Actinium	Ac	89	227
Aluminum	Al	13	26.98
Americium	Am	95	243
Antimony	Sb	51	121.8
Argon	Ar	18	39.95
Arsenic	As	33	74.92
Astatine	At	85	210
Barium	Ba	56	137.3
Berkelium	Bk	97	247
Beryllium	Be	4	9.012
Bismuth	Bi	83	209.0
Bohrium (Nielsbohrium)	Bh	107	262
Boron	B	5	10.81
Bromine	Br	35	79.90
Cadmium	Cd	48	112.4
Calcium	Ca	20	40.08
Californium	Cf	98	249
Carbon	C	6	12.01
Cerium	Ce	58	140.1
Cesium	Cs	55	132.9
Chlorine	Cl	17	35.45
Chromium	Cr	24	52.00
Cobalt	Co	27	58.93
Copper	Cu	29	63.55

Continued on next page.

[1] ACS names are the same except elements 105 and 107, where the ACS name is in parentheses.

Periodic Chart

1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 98	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.7	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po 209	85 At 210	86 Rn 222
87 Fr 223	88 Ra 226.0	89 Ac 227.0	104 Unq 257	105 Unp 260	106 Unh 263	107 Uns 262	108 Uno 265	109 Une 266									

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm 145	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	94 Pu 244	95 Am 243	96 Cm 247	97 Bk 247	98 Cf 251	99 Es 252	100 Fm 257	101 Md 258	102 No 259	103 Lr 260

APPENDIX I

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TITLE 40--PROTECTION OF ENVIRONMENT

CHAPTER I--ENVIRONMENTAL PROTECTION AGENCY (CONTINUED)

PART 136--GUIDELINES ESTABLISHING TEST PROCEDURES FOR THE ANALYSIS OF POLLUTANTS--Sec. 136.3 Identification of test procedures.

(a) Parameters or pollutants, for which methods are approved, are listed together with test procedure descriptions and references in Tables IA, IB, IC, ID, and IE. The full text of the referenced test procedures are incorporated by reference into Tables IA, IB, IC, ID, and IE. The references and the sources from which they are available are given in paragraph (b) of this section. These test procedures are incorporated as they exist on the day of approval and a notice of any change in these test procedures will be published in the Federal Register. The discharge parameter values for which reports are required must be determined by one of the standard analytical test procedures incorporated by reference and described in Tables IA, IB, IC, ID, and IE, or by any alternate test procedure which has been approved by the Administrator under the provisions of paragraph (d) of this section and Secs. 136.4 and136.5 of this part 136. Under certain circumstances (Sec. 136.3 (b) or (c) or 40 CFR 401.13) other test procedures may be used that may be more advantageous when such other test procedures have been previously approved by the Regional Administrator of the Region in which the discharge will occur, and providing the Director of the State in which such discharge will occur does not object to the use of such alternate test procedure.

Table IA. List of Approved Biological Methods

Parameter and units	Method [1]	EPA	Standard Methods, 18th Ed.	ASTM	USGS
Bacteria:					
1. Coliform (fecal), number per 100 mL.	Most Probable Number (MPN), 5 tube, 3 dilution, or	p. 132 [3]	9221C E [4]		
	Membrane filter (MF), single step.[2]	p. 124 [3]	9222D [4]	B-0050-85 [5]	
2. Coliform (fecal) in presence of chlorine, number per 100 mL.	MPN, 5 tube, 3 dilution, or	p. 132 [3]	9221C E [4]		
	MF, single step [6].	p. 124 [3]	9222D [4]		
3. Coliform (total), number per 100 mL.	MPN, 5 tube, 3 dilution, or	p. 114 [3]	9221B [4]		
	MF [2] single step or two step.	p. 108 [3]	9222B [4]	B-0025-85 [5]	

Continued on next page.

GLOSSARY

601-602. EPA GC methods for determination of volatile organic compounds by PID Hall detectors in series.

AA. Atomic absorption spectrometric method for metals.

Accuracy. The ability of a test to give the true amount of target analyte.

Acetonitrile partition. A technique for removing fat and oil interference from organic extracts.

Acid digestion. Method for obtaining metal analytes in solution for analysis.

Acid extractables. Organic analytes that are removed from acidified water with methylene chloride.

Acid-base partition. Clean-up technique for organic analysis.

Activated carbon. Carbon heated to 900 ˚C in the absence of oxygen.

Activated charcoal. Charcoal heated to 900 ˚C in the absence of oxygen.

Acute. Immediate effects.

Alkalinity. A measure of the acid-neutralizing ability of the sample.

Ames Test. A common screening test for mutagenic properties.

Analyte-free water. Water that has been treated to remove impurities of interest.

Analytical balance. Electronic balance capable of accurate weighings to 0.1 mg.

Analytically valid. Term used to indicate a procedure has been performed with sufficient controls to assure a high degree of confidence in the result.

Appendix I. Municipal landfill leachate monitoring list for detection, 40 CFR 258

Appendix II. Municipal landfill leachate monitoring list for assessment, 40 CFR 258

Appendix VIII. Hazardous substances list, 40 CFR 261

Appendix IX. Groundwater monitoring list, 40 CFR 264

Areal composite sample. Samples taken over an area then mixed to give an overall analysis of the site.

Areal domain. Samples taken at a variety of points within a larger sampling site.

Ascarite. A sodium hydroxide treated asbestos.

Ash. Residue left from a sample after heating to 555 ˚C.

Atomic absorption. Method of analysis based on atomizing a metal sample in a flame and monitoring the absorption of specific wavelengths of light passed through the flame.

ATP. Adenosine triphosphate, a polyphosphate biochemical.

Audits. Examination of test procedures or other laboratory processes and com-

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