

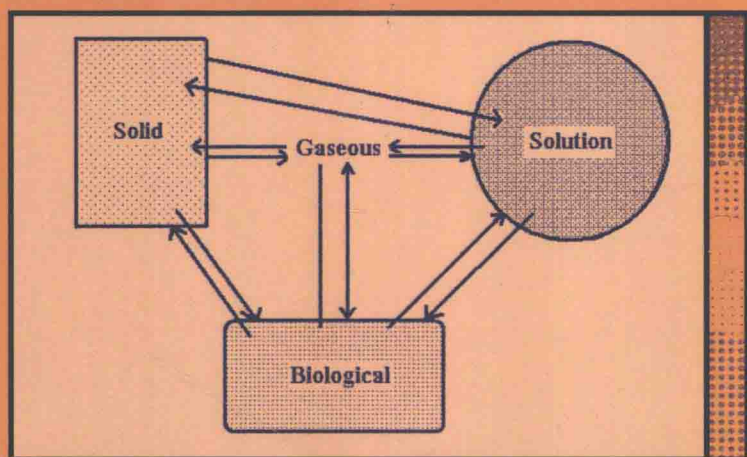
Chemical Analysis: A Series of Monographs on
Analytical Chemistry and Its Applications

Mark F. Vitha, Series Editor

Introduction to Soil Chemistry

Analysis and Instrumentation

SECOND EDITION



ALFRED R. CONKLIN JR.

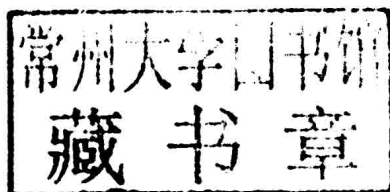
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Introduction to Soil Chemistry

CHEMICAL ANALYSIS

A SERIES OF MONOGRAPHS ON ANALYTICAL CHEMISTRY
AND ITS APPLICATIONS

Series Editor
MARK F. VITHA

Volume 178

A complete list of the titles in this series appears at the end of this volume.

PREFACE

The author is both a soil scientist and a chemist. He has taught courses in all areas of chemistry and soil science, analyzed soil, for organic and inorganic compounds, in both soil solids and extracts, using various methods and instruments, for 44 years. *Introduction to Soil Chemistry, Analysis and Instrumentation, 2nd Edition*, is the result of these 44 years of experience in two distinct climatic zones in the Philippines, four countries in Africa, and one in Central and one in South America. In the United States, this experience includes analysis of soils from all sections of the country.

This book is intended as a reference for chemists and environmentalists who find that they need to analyze soil, interpret soil analysis, or develop analytical or instrumental analyses for soil. Soil scientists will also find it valuable when confronted by soil analyses that are not correct or appear to be incorrect or when an analysis does not work.

There are two themes in this work: (1) that all soil is complex and (2) that all soil contains water. The complexity of soil cannot be overemphasized. It contains inorganic and organic atoms, ions, and molecules in the solid, liquid, and gaseous phases. All these phases are both in quasi equilibrium with each other and are constantly changing. This means that the analysis of soil is subject to complex interferences that are not commonly encountered in standard analytical problems. The overlap of emission or absorption bands in spectroscopic analysis is but one example of the types of interferences likely to be encountered.

Soil is the most complicated of materials and is essential to life. It may be thought of as the loose material covering the dry surface of the earth, but it is much more than that. To become soil, this material must be acted upon by the soil-forming factors: time, biota, topography, climate, and parent material. These factors produce a series of horizons in the soil that make it distinct from simply ground-up rock. Simply observing a dark-colored surface layer overlaying a reddish layer shows that changes in the original parent material have taken place. The many organisms growing in and on soil including large, small, and microscopic plants, animals, and microorganisms also make soil different from ground-up rock.

There are physical changes constantly taking place in soil. Soil temperature changes dramatically from day to night, week to week, and season to season. Even in climates where the air temperature is relatively constant, soil temperatures can vary by 20° or more from day to night. Moisture levels can change

from saturation to air dry. These changes have dramatic effects on the chemical reactions in the soil. Changes in soil water content change the concentration of soil constituents and, thus, also their solubility and reaction rate.

Not only are soil's physical and observable characteristics different from ground-up rock, so also are its chemical characteristics. Soil is a mixture of inorganic and organic solids, liquids, and gases. In these phases, inorganic and organic molecules, cations, and anions can be found. Inorganic and organic components can be present as simple or complex ions. Crystalline materials occur having different combinations of components, for example, 1:1 and 2:1 clay minerals, leading to different structures with different physical and chemical characteristics with different surface functionalities and chemical reactivities.

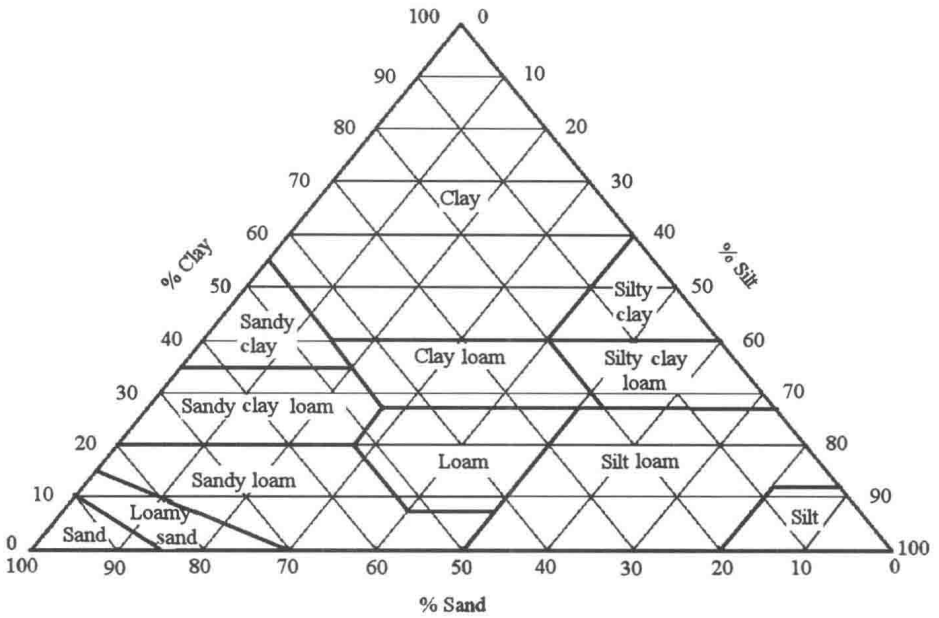
Organic components range from simple gaseous compounds, such as methane, to very complex materials such as humus. Included in this mix are gases, liquids, and solids, and hydrophobic and hydrophilic molecules and ions. All organic functional groups are included in soil organic matter, and it is common to find polyfunctional organic molecules as well as simple and complex biochemicals. Humus is an example of a complex molecule that contains many different functional groups. Both polyfunctional organic molecules and biochemicals coordinate and chelate with inorganic materials in soils, particularly metals.

The fact that soil always contains water, or more precisely an aqueous solution, is extremely important to keep in mind when carrying out an analytical procedure because water can adversely affect analytical procedures and instrumentation. This can result in an over- or under-determination of the concentrations of components of interest. Deactivation of chromatographic adsorbents and columns and the destruction of sampling tools such as salt windows used in infrared spectroscopy are examples of the potential deleterious effects of water. This can also result in absorbance or overlap of essential analytical bands in various regions of the spectrum.

This *Second Edition* continues the basic approach of the first with the addition of four chapters. Chapter 1 is an outline of the development of soil chemistry with specific reference to the development of instruments that have been essential to the present understanding of soil chemistry. Chapter 7 is a new chapter dealing with soil sampling, both in the field and in the laboratory, soil water sampling, sample transport, and storage. Chapter 8 discusses direct, modified, and indirect methods of soil analysis. Chapter 15 covers the recent development of hyphenated instrumental methods and their application to soil analysis.

Chapters 11 and 12 are the result of separating Chapter 7 from the *First Edition* into two chapters. Chapter 11 deals specifically with the extraction of inorganic analytes and Chapter 12 deals with organic analyte extraction.

All physical and chemical characteristics of soil have a pronounced effect on its analysis. The intention here is to first investigate some of the most important characteristics of soil and its extracts that impact its analysis, as well



Textural triangle

as the instrumentation applied to its analysis, and to elucidate those interferences that may be most troubling.

Chapters conclude with a list of references followed by a bibliography. The bibliography lists general sources for the material covered in the chapter, while the references give some specific examples illustrating the application to soil. These provide the reader with additional resources and examples of how the material in the chapter is actually used in soil analysis and research. These also provide a source of standard methods and procedures of soil analysis and provide the reader with pitfalls and interferences that may be encountered in the particular analysis being discussed.

The Internet references given have been checked and were found accurate at the time of writing. However, Internet addresses are subject to change. If unable to find an address, try accessing the parent organization and looking for the desired information through its home page. For instance, if the Internet address for a USDA (United States Department of Agriculture) site is not found, one can access the USDA home page and find the needed information from there.

The author wishes to thank D. Meinholtz, J. Bigham, N. Smeck, H. Skipper, B. Ramos, T. Villamayer, J. Brooks, M. Goldcamp, M. Anderson, T. Stilwell, M. Yee, N. Gray, L. Baker, J. Shumaker, Audrey McGowin, and E. Agran for their help in reviewing this manuscript. I would also like to thank M. Vitha for his help in preparing the manuscript.

ALFRED R. CONKLIN, JR.

INSTRUMENTAL METHOD ACRONYMS

AA	Atomic Absorption
DTA	Differential Thermal Analysis
FID	Flame Ionization Detector
FT-IR	Fourier Transform Infrared (spectroscopy)
GC	Gas Chromatography
HG	Hydride Generator
HPLC	High-Precision Liquid Chromatography or High-Pressure Liquid Chromatography
ICP	Inductively Coupled Plasma
LC	Liquid Chromatography
MS	Mass Spectrometry
NMR	Nuclear Magnetic Resonance (spectroscopy)
TA	Thermal Analysis
TCD	Thermal Conductivity Detector
TLC	Thin-Layer Chromatography
UHPLC	Ultra-High-Pressure Liquid Chromatography
UV-Vis	Ultraviolet-Visible (spectroscopy)
XAS	X-ray Spectroscopy
XANS	X-ray Near-Edge Spectroscopy
XRD	X-ray Diffraction
XRF	X-ray Fluorescence

Common Hyphenated Instrumental Method Abbreviations

Hyphenated Method	Separation Method	Modification	Identification Method
GC-MS	Gas chromatography	None	Mass spectrometry
HPLC-MS	High-precision liquid chromatography	None	Mass spectrometry
LC-ICP	Liquid chromatography	None	Inductively coupled plasma
LC-AAS	Liquid chromatography	Hydride derivatization	Atomic absorption spectroscopy
TA-MS	Thermal analysis	None	Mass spectrometry
DTA-MS	Differential thermal analysis	None	Mass spectrometry
LC-ICP-MS	Liquid chromatography	Inductively coupled plasma	Mass spectrometry
GC-IR-MS	Gas chromatography	Infrared spectroscopy	Mass spectrometry

Abbreviated Periodic Table of the Elements

1 H 1.0																	2 He 4.0
3 Li 6.9	4 Be 9.0															9 F 18.9	10 Ne 20.1
11 Na 22.9	12 Mg 24.3															17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.0	21 Sc 44.9	22 Ti 47.8	23 V 50.9	24 Cr 51.9	25 Mn 54.9	26 Fe 55.8	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.3	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 78.9	35 Br 79.9	36 Kr 83.8
37 Rb 85.4	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc 98	44 Ru 101.0	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 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	71 Lu 175.0	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 196.9	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 208.9	84 Po 209	85 At 210	86 Rn 222
87 Fr 223	88 Ra 226.0	103 Lr 257	104 Rf 261	105 Db 262	106 Sg 263	107 Bh 262	Lanthanide and Actinide series not shown										

CONTENTS

PREFACE	xi
INSTRUMENTAL METHOD ACRONYMS	xiv
COMMON HYPHENATED INSTRUMENTAL METHOD ABBREVIATIONS	xv
ABBREVIATED PERIODIC TABLE OF THE ELEMENTS	xvi
CHAPTER 1 SUMMARY OF THE HISTORY OF SOIL CHEMISTRY	1
1.1 The 19th Century	3
1.2 The End of the 19th and the Beginning of the 20th Century	8
1.3 The 20th Century	11
1.4 The End of the 20th and the Beginning of the 21st Century	14
1.5 Conclusion	15
Problems	15
References	16
Bibliography	18
CHAPTER 2 SOIL BASICS PART I: LARGE FEATURES	19
2.1. Horizonation	28
2.2 Peds	33
2.3 Soil Color	36
2.4 Soil Naming	38
2.5 The Landscape	39
2.6 Relationship of Large Features to Soil Chemistry, Soil Analysis, and Instrumentation	40
2.7 Conclusions	42
Problems	42
References	43
Bibliography	43

CHAPTER 3	SOIL BASICS PART II: MICROSCOPIC TO ATOMIC ORBITAL DESCRIPTION OF SOIL CHEMICAL CHARACTERISTICS	44
	Soil Components Independent	45
3.1	Soil Solids	45
	Soil Components Interacting	53
3.2.	Bonding Considerations	53
	Soil Components in Combination	58
3.3	Surface Features	58
3.4	Energy Considerations	60
3.5	Reaction Paths	61
3.6	Steric Factors	62
3.7	Rate Factors	62
3.8	All Factored Together	63
3.9	Micelles	63
3.10	Coated Surfaces	63
3.11	Conclusions	65
	Problems	65
	References	66
	Bibliography	67
CHAPTER 4	SOIL BASICS PART III: THE BIOLOGICAL AND ORGANIC COMPONENTS IN SOIL	68
	Biota of Soil	69
4.1	Animals	69
4.2	Plants	71
4.3	Microorganisms	75
	Biological and Organic Chemicals of Soil	79
4.4	Biochemical	79
4.5	Bioorganic	81
4.6	Organic Compounds	81
4.7	Analysis	87
4.8	Conclusions	89
	Problems	90
	References	90
	Bibliography	92
	Web Sites	92

CHAPTER 5	SOIL BASICS PART IV: THE SOIL AIR AND SOIL SOLUTION	93
5.1	Soil Air	94
5.2	Water	95
5.3	Solubility	98
5.4	Elements in Solution	99
5.5	Dissolved Gases	99
5.6	Compounds in Solution	100
5.7	Inorganic Ions in Solution	102
5.8	Organic Ions in Solution	104
5.9	Soil pH	105
5.10	The Soil Solution around Particles	106
5.11	Distribution between Soil Solids and Soil Solution	106
5.12	Oxidative and Reductive Reactions in the Soil Solution	108
5.13	Measuring Soil Water	109
5.14	Conclusion	112
	Problems	112
	References	113
	Bibliography	114
 CHAPTER 6	 SPECIATION	 115
6.1	Cations	118
6.2	Anions	123
6.3	Isolation of Species	128
6.4	Sampling, Sample Storage, and Speciation	129
6.5	Conclusions	130
	Problems	131
	References	131
	Bibliography	134
 CHAPTER 7	 SOIL AND SOIL SOLUTION SAMPLING, SAMPLE TRANSPORT, AND STORAGE	 135
7.1	Field Sampling	136
7.2	Sampling Cropped Land	147
7.3	Environmental Sampling	148
7.4	Other Environmental Sampling Situations	148
7.5	Sample Transport and Storage	148

7.6	Laboratory Sampling	149
7.7	Sampling the Soil Solution	153
7.8	Conclusions	155
	Problems	156
	References	157
	Bibliography	158
CHAPTER 8	DIRECT AND INDIRECT MEASUREMENT IN SOIL ANALYSIS	159
8.1	Direct Measurements	160
8.2	Mediated Direct Measurement	166
8.3	Indirect Soil Measurements	168
8.4	Destructive Soil Analysis Methods	170
8.5	Soil Solution	171
8.6	Soil Solids	171
8.7	Conclusions	172
	Problems	173
	References	173
	Bibliography	174
CHAPTER 9	ELECTRICAL MEASUREMENTS	175
9.1	The Basic Electrochemical Cell	177
9.2	Electricity Generation in Soil	177
9.3	Potentiometry (Electrodes in Soil Measurements)	178
9.4	Voltammetry	187
9.5	Electrical Conductivity	187
9.6	Time-Domain Reflectometry	188
9.7	Porous Block	189
9.8	Other Methods	189
9.9	Conclusions	189
	Problems	190
	References	190
	Bibliography	192
CHAPTER 10	TITRIMETRIC MEASUREMENTS	193
10.1	Soil Titration	195
10.2	Titration of Soil pH	197
10.3	Organic Matter	200
10.4	Ammonia	200

10.5	Kjeldahl: Organic Nitrogen	202
10.6	Nitrite and Nitrate	203
10.7	Carbonate Determination	204
10.8	Halogen Ion Determination	205
10.9	pH-Stat Titrations	206
10.10	Conclusions	207
	Problems	207
	References	208
CHAPTER 11	EXTRACTION OF INORGANICS	209
11.1	Extraction Equipment	210
11.2	Water as a Soil Extractant	211
11.3	Acid Extractants	218
11.4	Extractants for Basic Soils	222
11.5	Microwave-Assisted Extraction	224
11.6	Ultrasonic Extraction	225
11.7	Sequential Extraction	225
11.8	Ion Exchange Resin Extractions	226
11.9	Surfactants	227
11.10	Conclusion	227
	Problems	227
	References	228
	Bibliography	230
CHAPTER 12	EXTRACTION OF ORGANICS	231
12.1	Sampling Handling before Extraction	235
12.2	Extraction Equipment	235
12.3	Soil Organic Matter Extraction Solvents	243
12.4	Cleanup	247
12.5	Conclusion	250
	Problems	250
	References	251
	Bibliography	252
CHAPTER 13	CHROMATOGRAPHY	254
13.1	Fundamentals of Chromatography	256
13.2	Gas Chromatography	257
13.3	High-Performance Liquid Chromatography	264
13.4	Thin-Layer Chromatography	265

13.5	Electrophoresis	267
13.6	Identification of Compounds Separated by Chromatographic Procedures	268
13.7	Quantification	270
13.8	Conclusion	271
	Problems	271
	References	272
	Bibliography	273
CHAPTER 14	SPECTROSCOPY AND SPECTROMETRY	274
14.1	Spectral Overlap	275
14.2	Noise	276
14.3	The Visible Region	277
14.4	Ultraviolet Region	278
14.5	Infrared Spectroscopy	280
14.6	Nuclear Magnetic Resonance	286
14.7	Mass Spectrometry	287
14.8	Atomic Spectroscopy	288
14.9	Color Measurement: The Spectrophotometer	292
14.10	Regression Analysis	296
14.11	Relationship to the Original Sample	296
14.12	X-ray Diffraction	297
14.13	X-ray Fluorescence	297
14.14	Remote Sensing	299
14.15	Conclusion	299
	Problems	300
	References	300
	Bibliography	303
CHAPTER 15	HYPHENATED METHODS IN SOIL ANALYSIS	304
15.1	Sample Preparation	307
15.2	Sample Destroyed	307
15.3	Nondestructive Methods	313
15.4	Triple Hyphenated Methods	314
15.5	Conclusions	316
	Problems	316
	References	317
	Bibliography	318
INDEX		320