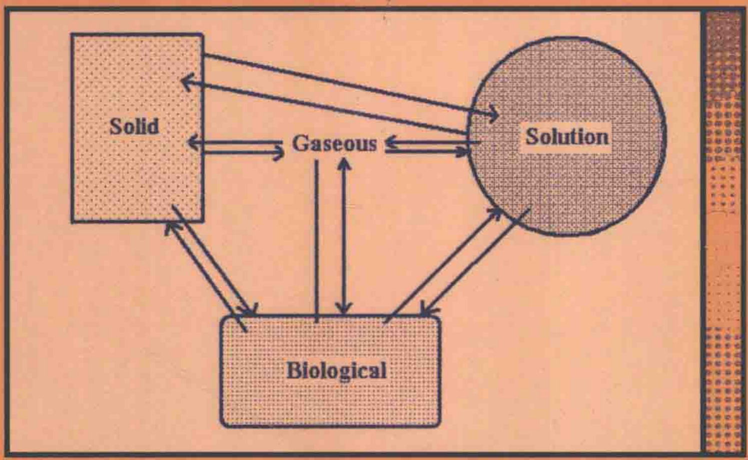
Chemical Analysis: A Series of Monographs on Analytical Chemistry and Its Applications
Mark F. Vitha, Series Editor

Introduction to Soil Chemistry

Analysis and Instrumentation

SECOND EDITION



ALFRED R. CONKLIN JR.

WILEY

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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.

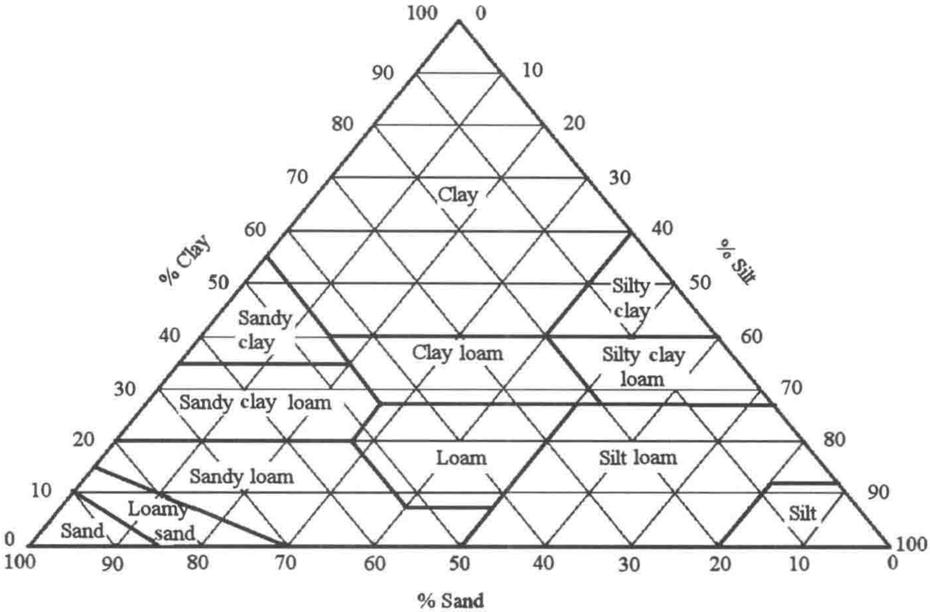
Organic components range from simple gaseous compounds, such as methane, to very complex materials such as humus. Included in this mix are gases, liquids, and solids, and hydrophobic and hydrophilic molecules and ions. All organic functional groups are included in soil organic matter, and it is common 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.

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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											5 B 10.8	6 C 12.0	7 N 14.0	8 O 15.9	9 F 18.9	10 Ne 20.1
11 Na 22.9	12 Mg 24.3											13 Al 26.9	14 Si 28.0	15 P 30.9	16 S 32.0	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										

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