CONTENTS

1 Organic Matter in Soils: Pools, Distribution, Transformations, and Function 1
   Pools of Organic Matter in Soils. 1
   Organic Matter (Humus) Content of Soils. 6
   Decomposition Processes and Ages of Organic Matter. 11
   Function of Organic Matter in Soil. 14
   Organic Matter and Sustainable Agriculture 19
   Environmental Significance of Humic Substances. 19
   Summary. 20
   References. 21

2 Extraction, Fractionation, and General Chemical Composition of Soil Organic Matter 24
   Brief Historical Review. 24
   Associations of Organic Matter in Soil. 34
   Extraction Methods. 34
   Fractionations Based on Solubility Characteristics. 41
   Purification. 45
   Classification and Distribution of Dissolved Organic C (DOC). 51
   Comparison of Soil Humic Substances with Those of Other Environments. 54
   Physical Fractionation of Organic Matter. 54
   Summary. 55
   References. 56
CONTENTS

3 Organic Forms of Soil Nitrogen 59

Fractionation of Soil N, 59
Nitrogen in Humic and Fulvic Acids, 66
Biochemical N Compounds, 71
Biomass N, 89
Natural Variations in N Isotope Abundance, 90
$^{15}$N-NMR Spectroscopy, 90
Stability of Soil Organic N, 90
Summary, 91
References, 92

4 Native Fixed Ammonium and Chemical Reactions of Organic Matter with Ammonia and Nitrite 96

Levels of Native Fixed NH$_4^+$ in Soils, 96
The C/N Ratio, 100
Chemical Reactions of NH$_3$ and NO$_2^-$ with Organic Matter, 102
Summary, 110
References, 111

5 Organic Phosphorus and Sulfur Compounds 113

The C/N/P/S Ratio, 113
Soil Organic P, 115
Soil Organic S, 128
Summary, 137
References, 137

6 Soil Carbohydrates 141

Significance of Soil Carbohydrates, 142
Structure and Classification, 142
State in the Soil, 144
Quantitative Determination of Soil Carbohydrates, 154
Summary, 163
References, 164

7 Soil Lipids 166

Lipid Content of Soil Humus, 166
Function in Soil, 171
Composition, 175
Summary, 185
References, 185
8 Biochemistry of the Formation of Humic Substances

Major Pathways of Humus Synthesis, 188
The Lignin Theory, 191
The Polyphenol Theory, 197
Sugar–Amine Condensation, 206
Scheme for the Formation of Humic Substances, 208
Summary, 209
References, 210

9 Reactive Functional Groups

Elemental Content, 212
Methods of Functional Group Analysis, 214
Distribution of Oxygen-Containing Functional Groups, 226
Diagenetic Transformations, 231
Summary, 234
References, 234

10 Structural Components of Humic and Fulvic Acids as Revealed by Degradation Methods

Experimental Approaches, 236
Hydrolysis Methods, 238
Reductive Cleavage, 240
Oxidative Methods, 248
Miscellaneous Chemical Approaches, 254
Thermal Methods, 255
Summary, 256
References, 257

11 Characterization of Soil Organic Matter by NMR Spectroscopy and Analytical Pyrolysis

Theory of Nuclear Magnetic Resonance Spectroscopy (NMR), 259
Techniques for $^{13}$C-NMR Spectroscopy, 263
$^{13}$C-NMR Spectroscopic Analysis of Humic and Fulvic Acids, 265
$^{13}$C-NMR Spectroscopic Analysis of Soil Organic Matter In Situ, 272
$^1$H-NMR Spectroscopy, 274
$^{15}$N-NMR Spectroscopy, 276
$^{31}$P-NMR Spectroscopy, 277
Analytical Pyrolysis, 277
Summary, 281
References, 281
12 Structural Basis of Humic Substances 285
   General Considerations, 286
   Type Structures for Humic and Fulvic Acids, 287
   Unique Feature of Humic Substances in Seawater, 294
   A Simplified Structural Representation of Soil Humic
   Substances, 294
   Summary, 301
   References, 301

13 Spectroscopic Approaches 303
   Ultraviolet (UV) and Visible Regions, 304
   Infrared (IR) Spectroscopy, 307
   Electron Spin Resonance (ESR) Spectroscopy, 317
   Fluorescence Spectroscopy, 322
   Summary, 322
   References, 323

14 Colloidal Properties of Humic Substances 325
   The Colloidal State, 325
   Molecular Weights and Particle Sizes, 326
   Morphological Features by Electron Microscopy, 339
   Structural Evaluation by X-Ray Diffraction, 341
   Small-Angle X-Ray Scattering, 342
   Size Evaluation by Gel Filtration, 343
   Summary, 347
   References, 348

15 Electrochemical and Ion-Exchange Properties of Humic
   Substances 350
   Acidic Nature of Humic and Fulvic Acids, 351
   Selectivity of Humic Substances for Exchange Cations, 367
   Contribution of Organic Matter to the Cation-Exchange
   Capacity (CEC) of the Soil, 367
   Coagulation of Humic Substances by Polyelectrolytes, 372
   Electrophoresis, 373
   Oxidation–Reduction Potential, 374
   Summary, 375
   References, 375

16 Organic Matter Reactions Involving Metal Ions in Soil 378
   Properties of Metal–Organic Matter Complexes 379
   Significance of Chelation Reactions in Soil, 381
   Forms of Transition Metal Ions in Soil, 384
Biochemical Compounds as Chelating Agents, 388
Trace Metal Interactions with Humic Substances, 394
Summary, 401
References, 401

17 Stability Constants of Metal Complexes with Humic Substances
General Considerations, 405
Modeling Approaches, 408
Summary, 427
References, 427

18 Clay–Organic Complexes and Formation of Stable Aggregates
Nature of Clay Colloids, 429
Adsorption of Defined Organic Compounds by Clay, 431
Naturally Occurring Clay–Organic Complexes, 439
Role of Organic Matter in Forming Stable Aggregates in Soil, 445
Soil Wettability, 449
Summary, 450
References, 450

19 Organic Matter Reactions Involving Pesticides in Soil
Humus Chemistry in Relation to Pesticide Behavior, 455
Adsorption Mechanisms, 462
Relative Affinities of Pesticides for Soil Organic Matter, 469
Summary, 469
References, 469

20 Role of Organic Matter in Pedogenic Processes
Weathering of Rocks and Minerals, 473
Neogenesis of Minerals, 477
Translocation of Mineral Matter and Horizon Differentiation, 478
Organic Matter and Soil Classification, 483
Paleohumus, 485
Effects of Acidic Inputs (Acid Rain) on Pedogenic Processes, 485
Summary, 486
References, 486

Index 489