

CONTENTS

VOLUME VI

Soils and Soil Sciences **1**
Willy H. Verheye, *National Science Foundation Flanders, Belgium and Geography Department
University Gent, Belgium*

1. Introduction
2. Soils And Soil Science
3. Soil Formation And Soil Forming Processes
 - 3.1. Weathering And Regolith Formation
 - 3.2. Soil Profile Formation And Horizon Development
4. The Soil Profile
5. Soil Composition And Soil Properties
 - 5.1. Soil Composition
 - 5.1.1. Organic Soils
 - 5.1.2. Mineral Soils
 - 5.2. Soil Texture
 - 5.3. Soil Structure
 - 5.4. Soil Consistence
 - 5.5. Soil Color
 - 5.6. Bulk Density And Soil Porosity
 - 5.7. Water Retention And Infiltration
 - 5.8. Soil Air And Aeration
 - 5.9. Organic Matter
 - 5.10. Soil PH
 - 5.11. Cation Exchange Complex
6. Soil Survey And Classification
 - 6.1. Types Of Soil Surveys
 - 6.2. Soil Survey Procedures
 - 6.3. Purpose And Use Of Soil Maps
 - 6.4. Soil Classification

A Brief History of Soil Science **40**
Eric C. Brevik, *Departments of Natural Sciences and Agriculture and Technical Studies, Dickinson
State University, Dickinson, ND, USA*

1. Introduction
2. Soil Science/Agriculture In Ancient Times And Early History (Up To 4th Century AD)
 - 2.1. Mesopotamia
 - 2.2. Greeks And Romans
 - 2.3. Other Mediterranean Civilizations
 - 2.4. Northern Europe
 - 2.5. Asia
 - 2.6. Americas
 - 2.7. Ancient Times And Early History Summary
3. Soil Science In The Middle Ages (5th To 14th Centuries AD)
 - 3.1. Byzantium And Europe
 - 3.2. Arabia And The Middle East
 - 3.3. Southeast Asia
4. Soil Science In The Renaissance Period (15th To 17th Centuries)
 - 4.1. Studies In Soils And Plant Nutrition
 - 4.2. Soils And Government
 - 4.3. Soils Recognized By Geologists
 - 4.4. Drainage Of Wet Soils

5. Soil Science In The Age Of Enlightenment (18th Century)
 - 5.1. The "Humus Theory"
 - 5.2. Soil As An Evolutionary Body
 - 5.3. Beginnings Of Soil Mapping
6. Soil Science Becomes A True Science (19th Century)
 - 6.1. Lewis And Clark
 - 6.2. The "Mineral Theory"
 - 6.3. Agrogeology
 - 6.4. Soil Mapping
 - 6.5. Darwin And Soil Biology
 - 6.6. The Profile Concept
 - 6.7. Dokuchaiev And The Birth Of Genetic Soil Science
7. Modern Soil Science (20th Century)
 - 7.1. Genetic Soil Science Spreads
 - 7.2. National Detailed Mapping Programs
 - 7.3. Soil Erosion
 - 7.4. The Internationalization Of Soil Science
 - 7.5. Soil Science Moves Beyond Agriculture
8. Concluding Remarks

Pedogenesis and Soil Forming Factors

64

Antonie Veldkamp, *Wageningen Agricultural University, Department of Environmental Sciences, Wageningen, The Netherlands*

1. Pedogenesis And Soil Forming Factors
 - 1.1. Organic Surface Horizon
 - 1.2. Hydromorphism
 - 1.3. Textural Differentiation
 - 1.4. Calcic, Gypsiferous And Saline Properties
 - 1.5. Vertic Properties
 - 1.6. Podzolization
 - 1.7. Andic Properties
 - 1.8. Ferralitization
 - 1.9. Chronosequences
2. Soil Properties Affecting Land Use Potential
 - 2.1. Properties Affected By Climate
 - 2.1.1. Wet (Sub)Tropical Climates
 - 2.1.2. (Semi) Arid Climates
 - 2.1.3. Steppe Climates
 - 2.1.4. (Sub)Humid Temperate Climates
 - 2.1.5. Permafrost Conditions
 - 2.2. Properties Affected By Parent Material
 - 2.3. Properties Affected By Topography
 - 2.4. Properties Affected By Age
 - 2.5. Properties Affected By Man
3. Soil Variability
4. How Do Soil Properties Affect Land Use And Land Cover
 - 4.1. Properties That Can Be Changed At Short Notice
 - 4.2. Properties That Can Be Partly Modified
 - 4.3. Properties That Cannot Be Changed With Current Management Techniques
5. How Land Use Affects Soil Properties
 - 5.1. Land Use Intensification
 - 5.1.1. Long Term Cultivation
 - 5.1.2. Multiple Cropping Systems
 - 5.1.3. Irrigation
 - 5.2. Land Use Conversion
 - 5.2.1. Conversion Of Forest

- 5.2.2. Conversion Of Grasslands
- 5.2.3. Conversion Of Coastal Wetlands
- 6. Discussion And Conclusions

Soil Properties and Pedometrics

86

Richard Murray Lark, *Biomathematics and Bioinformatics Division, Rothamsted Research, Harpenden, Hertfordshire, United Kingdom.*

- 1. Introduction
- 2. Origins Of Pedometrics
- 3. Mathematical And Statistical Techniques Used By Pedometricians
 - 3.1. Well-Established Workhorses
 - 3.1.1. Geostatistics
 - 3.1.2. Multivariate Analysis
 - 3.1.3. Fuzzy Sets
 - 3.2. Emerging Methodologies
 - 3.2.1. Bayesian Maximum Entropy
 - 3.2.2. Wavelet Transforms
- 4. Some Applications And Preoccupations
 - 4.1. Precision Agriculture
 - 4.2. Digital Soil Mapping
 - 4.3. Soil Monitoring
- 5. Future Prospects
 - 5.1. Pedogenesis in a Data Rich Environment
 - 5.2. Pedometrics And The Management Of Pedodiversity
 - 5.3. Pedometrics As A Unifying Discipline

Soil Geography and Classification

110

Otto Coenraad Spaargaren, *ISRIC - World Soil Information, Wageningen, The Netherlands*
 Jozef August Deckers, *Division Soil and Water Management, Catholic University of Leuven, Belgium*

- 1. Introduction
- 2. The Zonal Concept In Soil Classification – A Historical Overview
- 3. Modern Soil Classifications
 - 3.1. Soil Geography And Soil Taxonomy
 - 3.2. Soil Geography And The FAO/UNESCO Soil Map Of The World
 - 3.3. Soil Geography And The World Reference Base For Soil Resources (WRB)
 - 3.4. Soil Geography And Other Systems Of Soil Classification
- 4. Role Of Soil Geography And Soil Classification In Land Use Planning And Land Cover Studies

Soil Physics

126

Willy R. Dierickx, *Retired from Ministry of the Flemish Community, Institute for Agricultural and Fisheries Research, Technology and Food Unit, Agricultural Engineering, Merelbeke, Belgium*

- 1. Introduction
- 2. Soil Texture
 - 2.1. Mineral Soil Fractions
 - 2.1.1. Sand
 - 2.1.2. Silt
 - 2.1.3. Clay
 - 2.2. Organic Soil Fraction
 - 2.3. Particle Size Distribution
 - 2.3.1. Particle Size Analysis

- 2.3.2. Cumulative Particle Size Distribution Curve
- 2.3.3. Textural Triangle
- 3. Soil Structure
 - 3.1. Soil Structure Classification
 - 3.2. Soil Structure Characterization
 - 3.3. Aggregate Stability
- 4. Soil Physical Properties
 - 4.1. Specific Soil Surface
 - 4.2. Soil Density
 - 4.2.1. Particle Density
 - 4.2.2. Bulk Density
 - 4.3. Porosity And Void Ratio
 - 4.3.1. Porosity
 - 4.3.2. Void Ratio
 - 4.4. Water Content
 - 4.5. Plasticity Index
- 5. Soil Hydraulic Properties
 - 5.1. Saturated Hydraulic Conductivity
 - 5.2. Unsaturated Hydraulic Conductivity
- 6. Agricultural Significance
 - 6.1. Importance Of Texture
 - 6.2. Importance Of Structure
 - 6.3. Importance Of Other Soil Physical Characteristics
- 7. Conclusions

Soil Chemistry and Soil Fertility

153

Isam I. Bashour, *Faculty of Agricultural and Food Sciences, American University of Beirut, Bliss Street, Beirut, Lebanon.*

- 1. Introduction
- 2. Soil Forming Factors And Processes
- 3. Soil Chemical Reactions
 - 3.1. The Inorganic Solid Phase
 - 3.2. The Organic Solid Phase
 - 3.3. The Liquid Phase
 - 3.3.1. Infiltration
 - 3.3.2. Hydrolysis
 - 3.4. The Gaseous Phase
 - 3.4.1. Soil Air Quality
 - 3.4.2. Biochemical Effect Of Aeration
 - 3.5. Soil Acidity (PH)
 - 3.6. The Exchange Complex
 - 3.7. Oxidation And Reduction
- 4. Soil Fertility And Plant Nutrient Uptake
 - 4.1. Nutrient Fixation And Losses
 - 4.1.1. Macronutrients
 - 4.1.2. Micronutrients
 - 4.1.3. Beneficial Elements
 - 4.2. Fertilizer Application
 - 4.2.1. Solid Fertilizers
 - 4.2.2. Fluid Fertilizers (Liquid And Suspension)
 - 4.3. Amount And Time Of Application
 - 4.4. Fertilizer Mobility In Soils
 - 4.5. Fertilizer Salt Index
 - 4.6. Interactions And Environmental Effects
 - 4.6.1. Inorganic Fertilizers
 - 4.6.2. Organic Pollution Sources

5. Impact Of Soil Chemical Conditions On Land Use And Land Cover

Soil Biology And Microbiology

184

Andreas De Neergaard, *Department of Agricultural Sciences, Plant and Soil Science, Royal Veterinary and Agricultural University, Thorvalsenvej, 40, Frederiksberg, Denmark.*

1. Introduction
2. Soil Biota
 - 2.1. Microbiota
 - 2.1.1. Bacteria
 - 2.1.2. Fungi
 - 2.1.3. Cyanobacteria And Algae
 - 2.1.4. Protozoa
 - 2.1.5. Metabolism Of Micro-Organisms
 - 2.2. Mesobiota
 - 2.3. Macrobiota
3. Species Diversity And Interaction With Soil Properties
 - 3.1. Numbers And Species Diversity
 - 3.2. Interaction With Soil Water Content
 - 3.3. Interactions With Food Webs And Soil Metabolism
 - 3.4. Interaction With The Rhizosphere
4. Biological Processes In Soils
 - 4.1. Microbial Activity And Accumulation Of Biomass
 - 4.2. Litter Decomposition And Turnover
5. Soil Functionality And Its Change Under Stress
6. Indicators Of Soil Quality
7. Soil Biota And Land Use
8. Conclusions

Soil Biochemistry

205

Qiaoyun Huang, *Faculty of Resources and Environment, Huazhong Agricultural University, Wuhan 430070, China*

1. Introduction
2. Chemistry Of Soil Organic Matter
 - 2.1. Pools Of Organic Matter In Soils
 - 2.2. Formation Of Humic Substances
 - 2.2.1. The Lignin Theory
 - 2.2.2. The Polyphenol Theory
 - 2.2.3. Sugar-Amine Condensation
3. Soil Enzymes
 - 3.1. Classification By Location
 - 3.2. Classification By Function
 - 3.3. Properties Of Soil Enzymes
4. DNA In Soil
5. Carbon Cycling In Soil
 - 5.1. Decay Process
 - 5.2. Use Of ¹⁴C In Soil Organic Matter Studies
 - 5.3. Transformations In Wet Sediments
6. Biochemistry Of Soil Nitrogen
 - 6.1. Ammonification
 - 6.2. Nitrification
 - 6.3. Stabilization Of Soil Organic N
 - 6.4. Denitrification
 - 6.5. Use Of ¹⁵N In Soil Nitrogen Studies
7. Biochemistry Of Phosphorus And Sulfur In Soil

- 7.1. Phosphorus
- 7.2. Sulfur
- 8. Biochemical Interactions With Metals
 - 8.1. Complexation Of Metals With Soil Organic Components
 - 8.2. Biochemical Compounds As Chelating Agents
 - 8.3. Trace Metal Interactions With Humic Substances
- 9. Biochemistry Of Xenobiotics In Soil
 - 9.1. Effect Of Pesticides On Soil Processes
 - 9.2. Metabolism Of Pesticides In The Soil
- 10. Biochemistry Of The Rhizosphere
 - 10.1. Properties Of The Rhizosphere
 - 10.2. Use Of ¹⁴C In Rhizosphere Studies
 - 10.3. Modification Of The Rhizosphere
- 11. Future Developments In Soil Biochemistry

Soil Mineralogy

233

A.D. Karathanasis, *Department of Plant and Soil Sciences, University of Kentucky, Lexington, USA*

- 1. Introduction
- 2. Classification And Distribution Of Minerals
 - 2.1. Sulfides
 - 2.2. Oxides And Hydroxides
 - 2.3. Halides, Sulfates And Carbonates
 - 2.4. Phosphates
 - 2.5. Silicates
 - 2.5.1. Primary Silicate Minerals
 - 2.5.2. Secondary Silicate Minerals
- 3. Surface Properties Of Minerals
 - 3.1. Permanent And Variable Charge
 - 3.2. Water Sorption Characteristics
 - 3.3. Dispersion-Flocculation Phenomena
 - 3.4. Sorption Characteristics
 - 3.5. Surface Area Properties
- 4. Mineral Characterization Methods
 - 4.1. X-Ray Diffraction
 - 4.2. Thermal Analysis
 - 4.3. Optical Microscopy
 - 4.4. Elemental Analysis
- 5. Mineral Weathering
 - 5.1. Primary And Secondary Minerals
 - 5.2. Weathering Pathways
 - 5.3. Mechanisms Of Mineral Weathering
- 6. Land Use And Environmental Implications

Soil Microscopy And Micromorphology

261

Ewart Adsil Fitzpatrick, *School of Biological Science, University of Aberdeen, St. Machar Drive, Aberdeen, Scotland, UK.*

- 1. Introduction
- 2. Techniques
- 3. Definitions, Concepts And Features
- 4. Mineral Soil Material
 - 4.1. Primary Minerals And Particle Size Classes
 - 4.2. Secondary Minerals And Weathering Products
- 5. Organic Soil Material
 - 5.1. Plant Material, Roots And Rhizomes

- 5.2. Faunal Features
- 5.3. Microorganisms
- 6. Soil Micromorphological Mineral Features
 - 6.1. Fine Material And Matrix
 - 6.2. Domains
 - 6.3. Structure And Pores
 - 6.4. Coatings
 - 6.5. Impregnations, Concretions, Nodules And Concentrations
- 7. Applications
 - 7.1. Agriculture
 - 7.2. Archaeology
 - 7.3. Engineering
 - 7.4. Geomorphology
 - 7.5. Palaeo-Climatology
 - 7.6. Pedology And Palaeopedology
 - 7.7. Soil Microbiology
 - 7.8. Soil Zoology
- 8. Conclusions

Forest, Range and Wildland Soils **288**

M. Derek Mackenzie, *Department of Renewable Resources, University of Alberta, Edmonton, Canada*

- 1. Introduction
- 2. Ecosystems And Soil Orders
 - 2.1. Forest Ecosystems
 - 2.1.1. Boreal Systems
 - 2.1.2. Sub-Alpine Forest Systems
 - 2.1.3. Lowland Conifer Forest Systems
 - 2.1.4. Mixed And Pure Deciduous Forest Systems
 - 2.1.5. Broad-Leaf Evergreen Forest Systems
 - 2.1.6. Temperate Rainforest Systems
 - 2.2. Range Ecosystems
 - 2.2.1. Grassland Systems
 - 2.2.2. Semi-Desert Woodland Systems
 - 2.3. Wildland Systems
 - 2.3.1. Sclerophyllous Shrubs
 - 2.3.2. Alpine And Tundra Systems
- 3. Natural Disturbances And Soils
 - 3.1. Effects Of Fire
 - 3.2. Effects Of Canopy Gaps
 - 3.3. Effects Of Permafrost And Frozen Soils
- 4. Soil Organic Matter
 - 4.1. Carbon
 - 4.2. Nitrogen
 - 4.2.1. Nitrogen Fixation And Mineralization
 - 4.2.2. Plant/Soil/Microbe Interactions
 - 4.2.3. Fire: A Special Case
- 5. Management Risk Factors
 - 5.1. Forest Harvesting And Silviculture
 - 5.2. Livestock Grazing

Index **309**

About EOLSS **317**