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Soil-Water-Solute-Process Characterization: An Integrated Approach. JAVIER ÁLVAREZ-BENEDÍ and RAFAEL MUÑOZ-CARPENA (ed.) CRC Press, Boca Raton, London, New York, Washington, DC. Hardcover, 778 pp. $179.95. ISBN: 1–56–670657–2.

The characterization of soil-water-solute processes in the vadose zone is a major challenge in many disciplines, including the soil sciences, agricultural engineering, hydrology, geology, and soil remediation. Research in this area has progressed enormously in the last decade, especially with respect to novel measurement techniques but also in relation to the development and use of mathematical models caused by an apparently unlimited growth in computational power. Soil measurement technology and mathematical modeling of soil processes thus far have advanced both at their own pace and almost independently from one another. There is therefore a need to evaluate and reflect not only on measurement techniques presently available to characterize and monitor soil processes, but also on the use of this information to improve models and to predict the behavior of water and the fate of solutes and contaminants in the vadose zone. This book aims to fill this gap by providing scientists and practitioners with an integrated approach that will enable them to make appropriate choices in terms of available methods for characterizing soil-water-solute processes and models describing them.

The authors have organized their book into six sections, which cover three main parts. The first part, which is also the first section, defines the basis for an integrated approach of soil characterization. This section, which includes three chapters, sets the scene and provides a basis for the other two parts. The second part of the book deals with an extensive and critical evaluation of methods presently available to analyze and quantify energy and water transfer, chemical transport, and soil microbial processes. The third part covers the quantification of spatial and temporal variability in soil processes and transport modeling techniques. In the following, the three parts are discussed in more detail.

The first part contains three chapters. Chapter 1 presents a multidisciplinary approach for assessing subsurface nonpoint source (NPS) pollution. It proposes a six-stage methodology that can be followed to develop deterministic models for nonpoint-source pollution. The importance of scale and spatial variability in the parameterization process is discussed, including the role of GIS in upscaling model simulations. The role of spatial and temporal variations of soil processes in relation to studying soil-water-solute processes is the content of Chapter 2. This chapter provides the reader with a general discussion of the determinism and stochasticity of soil processes and the issue of scale in the design of field studies. Chapter 3 provides a short overview of general concepts and the mathematical description of soil-water-solute processes.

The two remaining parts are covered in 18 chapters that are organized into five sections (2–6). Section 2 deals primarily with energy and water transfer in soils (Chapters 4–8). Chapter 4 addresses the energy and water balance at the soil–plant–atmosphere interface and discusses the basic physical principles of the energy balance, as well as measurement techniques to quantify the major water balance terms like evapotranspiration, interception, and recharge. Remote sensing methods to quantify biophysical properties such as vegetation cover and soil moisture are also presented. Chapter 5 covers field methods to quantify the soil water status such as time domain reflectometry (TDR), frequency domain reflectrometry (FDR), tensiometers, resistance blocks, heat dissipation sensors, and soil psychrometers. Evaluation criteria for volumetric soil water monitoring methods and soil tensiometric methods are given that are extremely useful for designing experimental studies both in the laboratory and in the field. In Chapter 6 the measurement and characterization of soil hydraulic properties using in situ measurements is discussed. Common field methods are presented, including ring infiltrometers, well or borehole permeameters, and tension or disc infiltrometers. The presentation of these methods is accompanied by a clear description of the underlying physical principles. Chapter 7 presents new technologies such as nuclear magnetic resonance imaging (NMRI) and X-ray tomography to study soil–plant–water processes. This chapter provides a clear description of the fundamental physical principles of both methods. Applications are presented for each method. In Chapter 8, a brief introduction to the part of preferential flow processes and their mathematical formulation in soils is given.

Section 3 is devoted to chemical processes in soils (Chapters 9–14). In Chapter 9, field methods for monitoring solute transport are discussed. Direct and indirect methods are presented such as geophysically based techniques like the resistivity method and electromagnetic induction, but also emerging technologies such as fiber optic sensors. Chapter 10 provides a detailed evaluation of the merits and weaknesses of TDR as a measurement technique for studying solute transport in soils. This chapter is logically followed by a chapter dealing with the analysis and interpretation of breakthrough curves obtained from typical column experiments in the laboratory. In addition to standard methods for analyzing and interpreting breakthrough curves, this chapter also offers different experimental techniques for characterizing nonequilibrium solute transport in soils. The next chapter provides a brief analysis of different methods available to determine sorption–desorption processes of pesticides and organic compounds in soils. In Chapter 13, measurement methods to determine soil-surface gas fluxes, such as chamber techniques and mass exchange methods using micrometeorological techniques, are presented. These methods nicely complement the theoretical material in Chapter 4. Finally, the last chapter in this section provides a short overview of chemical methods available to analyze soil and water properties.

Methods for the characterization and evaluation of microbiological processes are addressed in Section 4 (Chapter 14). Although the authors have done a very good job tackling this important topic, one chapter alone is not sufficient to address the large set of methods currently available for the analysis of microbial processes, nor does it allow for a sufficiently comprehensive coverage of the various modeling approaches. More attention to this topic would have done better justice to the importance of microbial processes in determining the fate of contaminants in soils and in characterizing soils.

The last topic of the book addresses the issues of spatial variability and modeling. This part is organized into two sections (5–6). Section 5 addresses geostatistical methods and fractal approaches to characterize spatial variability of soil processes. Chapter 16 presents primarily the fundamentals of geostatistical methods, complete with a specific case study on the exploration of soil moisture–landscape relationships.

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The second chapter (17) in this section introduces concepts of fractal and multifractal techniques to describe soil variability. The potential of these techniques is illustrated using two field cases. The third chapter (18) provides an overview of the characterization of soil spatial variability using bulk electrical conductivity sampling for three different applications at the landscape scale: solute transport modeling in the vadose zone, site-specific crop management, and soil quality assessment. Section 6 describes modeling tools to predict leaching of solutes, primarily pesticides, and inverse approaches that can be used to characterize transport processes in the soil–plant continuum. Chapter 19 deals with the regionalization of one-dimensional pesticide models to larger scales and with the assessment of the uncertainty in predicting pesticide fluxes and concentrations that is inherently part of the regionalization process. In the second chapter (20) basic principles of inverse modeling are given. The potential of this approach is illustrated for the identification of unsaturated flow, transport, and crop growth parameters of the soil–plant–atmosphere continuum. The last chapter (21) follows Chapter 19 by outlining the important environmental fate processes of pesticides, their modeling, and their application to practical problems. The modeling topics presented in this book focus heavily on the description of physical transport and sorption–desorption processes. However, a presentation and discussion of modeling techniques to simulate biological processes or chemical reactions in soils is entirely missing.

In general, the editors and more than 50 authors have set themselves a very ambitious goal by wanting to provide an integrated approach for soil-water-solute processes. Given the broad range of topics addressed in this book, they have done the very best possible in formulating this approach and organizing the material accordingly. One of the major merits of the book is that each chapter addresses the strengths but also the weaknesses of the presented methods and techniques. Moreover, almost every chapter offers recommendations on how to select the appropriate method for the specific question at hand and includes a discussion of future research. One of the most interesting aspects of this book is that it covers not only the physical aspects of soil-water-solute-process characterization, but also discusses chemical processes and methods, microbial processes, energy balance considerations, and soil surface gas fluxes, topics that typically are not addressed in similar textbooks. These features distinguish this book from many others on the market. Moreover, this book offers a bridge between the major processes—physical, chemical, and biological—governing the fate of water and solutes in soil, and is therefore a valuable contribution to the literature on vadose zone processes.

The editing and layout of the book are done professionally. Special attention has been paid to the quality and the clarity of the figures. The style and quality of writing is inviting to the reader. The editors have done an excellent effort in ensuring continuity between chapters, both in style and content, despite the fact that each chapter is written by a different set of authors. Overall, I recommend this book to scientists from all of the earth science disciplines who want to obtain a comprehensive overview of general concepts, methods, and models in the field of soil-water-solute processes. The book provides a solid and broad basis to deal with one of the most complex systems in the natural sciences: soil.

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