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BOOK REVIEW

Book Review: "*Hydraulic Conductivity—Issues, Determination and Applications*", L. Elango (ed.), InTech, Croatia

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Hydraulic conductivity is probably the most important hydrogeological parameter, as it governs, along with other parameters, the flow of fluids and migration of contaminants beneath the ground surface, especially in soils and aquifers. There are already many books on broad aspects of hydrogeology and groundwater hydraulics that briefly review the determination of hydraulic conductivity. However, over the past several decades, due to the rapid development of science and technology and the ever-increasing groundwater extraction and contamination, many new theories, methodologies and applications regarding hydraulic conductivity have emerged. As a result, a book is needed to provide a useful collection of the current state of knowledge on the topic.

Hydraulic Conductivity—Issues, Determination and Applications, edited by L. Elango (ISBN 978-953-307-288-3, 446p.) was recently published by InTech, an open access publisher based in Croatia (Elango 2011). Just 7 months before the publication of this book, another book entitled "*Developments in Hydraulic Conductivity Research*", edited by Oagile Dikinya (2011), was published by the same publisher. Both these books report the latest advances of research within the hydraulic conductivity field of study and are worth reading, but the book by Elango (2011) is more extensive in content and has a more applied focus than the former one. It was published as open access, which enables everyone interested in this topic to read it free of charge, benefitting readers, authors, as well as science in general. Contributing authors come from around the world including Turkey, India, Brazil, Nigeria, Poland, Spain, USA, Iran, Germany, Canada, México, Taiwan, Italy, France, Bolivia, Thailand and Australia. This book is organized into five clustered themes, and comprises a total of 21 chapters. A reference list is appended at the end of each chapter, which includes several recent references that allow readers to gain further information on specific topics. However, a shortcoming is the lack of an abstract for each chapter, thus readers are unable to get a quick glance at the main findings of each chapter.

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The first part of the book is themed *Hydraulic Conductivity and Its Importance*, and comprises four chapters (Chapters 1 to 4). Chapter 1 presents the role of hydraulic conductivity in the simulation of surface water-groundwater interactions in wetlands. Three models presenting influences of hydraulic conductivity on surface water-groundwater interactions from different points of view are introduced and each is illustrated with a case study. Chapter 2 discusses the effects of puddling on soil hydraulic properties which are determined by various factors such as climate, soil texture, depth and intensity of puddling, bulk density and organic manures applications. Chapter 3 presents an experimental study on the variation of hydraulic conductivity due to mobility of heavy metals and Chapter 4 illustrates a modeling research, with the EPA HELP model, of the effects of hydraulic conductivity on the performance of the cover systems for remediating mineral wastes. Of the four chapters in this part, the first two deal with the role of hydraulic conductivity in water flow or mass transport, while the remaining two are linked to the effects of hydraulic conductivity in environmental protection. An extra chapter regarding groundwater resources evaluation or groundwater recharge estimation is strongly recommended, because hydraulic conductivity is an important parameter in such research. The effect of scale on hydraulic conductivity should also be discussed in a separate chapter, because it is an increasingly important topic in this field of study.

The second part consists of three chapters that deal with the relation of hydraulic conductivity and plants (Chapters 5 to 7). The first chapter in this part treats soil and plant as similar hydraulic systems, as they share similar basic hydraulic elements. The plant hydraulic system is an interesting theory that I heard of for the first time. I am sure there must be many others like me that have not heard about it before and will get interested in it. This chapter introduces the methods of determining soil hydraulic conductivity and the wood hydraulic system. Factors affecting hydraulic conductivity of Soil-Plant-Atmosphere Continuum (SPAC) model are also discussed. However, the measurement of plant hydraulic conductivity is not mentioned in this paper. The second chapter in this part is very closely related to the first one. Actually, it can be viewed as a supplementary of the first one, which focuses on root hydraulic conductivity that reflects root water uptake ability. This chapter discusses several factors influencing root hydraulic conductivity such as root anatomy, environmental stresses, light intensity, biological rhythm and plant nutrition. Most interestingly, several methods for measuring root hydraulic conductivity are introduced, which is a necessary supplement to Chapter 5. The last paper of this part discusses the effects of wildfire on soil hydraulic conductivities of forest, woodland and grassland. Soils and plants form an integrated hydrologic and hydraulic system. If one part of this system is destroyed or disturbed, the whole system will undergo notable changes. Inferred from the conclusions of the last chapter, it seems that there is still much work to be done in this interesting field. I am sure there will be more scholars participating in this field in the future and I am looking forward to seeing more significant discoveries in this field.

Parts three and four are alike in topic. Part three is composed of four chapters (Chapters 8 to 11) and presents determination of hydraulic conductivity by mathematical and laboratory methods, while part four comprises six chapters (Chapters 12 to 17), dealing with field techniques for determining this parameter. Chapter 8 introduces the pedotransfer functions which can be used for determining soil hydraulic properties by translating those easily measured soil properties such as bulk density, particle size distribution and organic matter content. Pedotransfer functions and corresponding computer models for estimating saturated and unsaturated hydraulic conductivities are introduced with some case studies interpreted. Chapters 9 and 10 present methods of estimating soil hydraulic conductivity from soil characteristics such as soil moisture content (Chapter 9) and soil texture, organic matter content, and soil depth (Chapter 10). Chapter 11 presents a detailed derivation of analytical

solutions for the 1-D and 2-D Green-Ampt problems. These analytical solutions are compared with numerical computations, verifying the essential role of hydraulic conductivity in both deriving analytical solutions and doing numerical computations. All these four chapters in part three present alternative ways of estimating soil hydraulic conductivity indirectly. As a matter of fact, hydraulic conductivity can also be measured directly through laboratory methods, although it may be much more costly and time consuming than using the indirect methods introduced in this book. Whereas, including a chapter presenting laboratory methods for measuring hydraulic conductivity directly will make this part much more comprehensive and complete.

Soil hydraulic conductivities estimated through mathematical and laboratory methods, either directly or indirectly, are somewhat untrustworthy sometimes because of misunderstanding and ill conceptualization of actual site conditions and scale effects of the estimated parameter. In such cases, field measurement of this parameter will be more desired. The first chapter in part four (Chapter 12), taking the study area around the Cuitzeo Lake watershed, Mexico as an example, introduces two automated infiltrometers with data loggers for measuring in situ soil hydraulic conductivity. Chapter 13 presents ten tracer tests carried out in karstic aquifers of the river Lobos Canyon, Spain under low water and flood conditions. This chapter reports many useful results for identifying the relationship of the river Lobos with the aquifer and vulnerability of the aquifer to pollution. However, it does not illustrate how to determine the hydraulic conductivity by these tracer tests in detail, despite the fact that it holds that these tests can be the basis for estimating the hydraulic conductivity. If examples of determining hydraulic conductivity by tracer tests had been provided in this chapter, that would be much better and useful. Chapter 14 proposes an empirical HC model for estimating rock mass hydraulic conductivity of highly disturbed clastic sedimentary rocks, which considers four parameters: rock quality designation (RQD), depth index (DI), gouge content designation (GCD), and lithology permeability index (LPI). This model, on one hand is based on a high-resolution borehole acoustic televiewer for characterizing lithology and fractures of the borehole that are essential to calculate rock mass permeability index (HC index), and on the other hand it is based on the double packer systems for conducting hydrogeological testing. After that a correlation can be established between HC and hydraulic conductivity, which can be further used to estimate hydraulic conductivity for different sites with similar lithological conditions. With infiltrometer tests in limestone and calcarenite as instances, authors of Chapter 15 demonstrate a methodology to obtain the field-saturated hydraulic conductivity by using a large diameter ring infiltrometer coupled with geophysical techniques. Large diameter ring infiltrometer can avoid the edge effects and the coupled geophysical techniques can help to monitor the water infiltration depth and allow a rapid visualization of the change in water content in the subsurface. Chapter 16 describes some electrokinetic techniques of determining hydraulic conductivity of formations and Chapter 17 presents hydraulic conductivity determination by seismic and acoustic methods with two field examples interpreted. Overall, the instrumentations or the methodologies for the determination of hydraulic conductivity introduced in this part are all aided or depend in full or partially on geophysical techniques, with the exception of the tracer tests introduced in Chapter 13. This reflects the continuous integration of hydrogeology and geophysics, and shows that hydrogeology has become truly multidisciplinary, putting forward higher requirements to hydrogeologists.

Part five of the book discusses in four chapters (Chapters 18 to 21) the applications of hydraulic conductivity in modeling. Chapter 18 introduces two methods for calculating the composite hydraulic properties that can be potentially used in simplifying the model layer while modeling. Chapter 19 reports a modeling study on the movement of water and potassium in soil under drip irrigation, in which hydraulic conductivity is a very important

parameter. With some similarity to Chapter 19, Chapter 20 presents a comprehensive model for predicting the movement of water and contaminants through unsaturated soil. The last chapter of this book proposes a Steady-State Centrifuge (SSC) method for measuring hydraulic conductivity of unsaturated soils. The last chapter, in my opinion, is more appropriate to be included in the third part of the book that focuses on the determination of hydraulic conductivity by mathematical and laboratory methods. With the rapid development of computer techniques, numerical modeling has been widely used in various hydrogeological studies. However, performing a quick and accurate modeling is still quite challenging even today when numerical modeling has been developed for scores of years, due to the complexity of actual geologic formations and uncertainty associated with modeling research (Li 2014). The four chapters included in this part of the book report many interesting and practical studies in the field of groundwater modeling. For example, results reported in Chapter 18 are especially helpful in numerical modeling, because determining an appropriate number of layers is critical for the accuracy and simplicity of numerical modeling. Chapters 19 and 20 both focus on numerical modeling of water movement and mass transport in unsaturated soils, which is a hot and essentially important research field in recent years, receiving a great deal of attention from international hydrogeologists and hydrologists. However, to make the book more comprehensive, I would suggest to also include in this part some chapters regarding numerical modeling research of saturated porous media.

In spite of some minor grammatical errors and editing defects, this book delivers a lot of new knowledge and technologies to hydrogeological and environmental researchers and students. The plant hydraulic system theory introduced in this book is of special interest to me and many other hydrogeologists, environmentalists and ecologists, and the methods for determining hydraulic conductivity introduced in this book will be helpful for engineers and practitioners. Prof. L. Elango is an eminent hydrogeologist at Anna University in India, specialized in various areas including hydrochemistry, hydrogeophysics and groundwater modeling. He has published nearly 200 research papers in international journals and conferences and has edited seven books. His expertise ensures that the book is edited and compiled scientifically, covering many interesting topics. Overall, this book is worth reading and will enhance the reader's appreciation of the importance of hydraulic conductivity on various fields related to hydrogeology and environment science. I am sure if some of the methods or technologies are adopted in one's own research, he/she will gain more chances of success. Therefore, I recommend this book to hydrogeological professionals, students, researchers and anyone who may be interested in this field. It is available at http://www.intechopen.com/books/hydraulic-conductivity-issues-determination-and-applications.

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