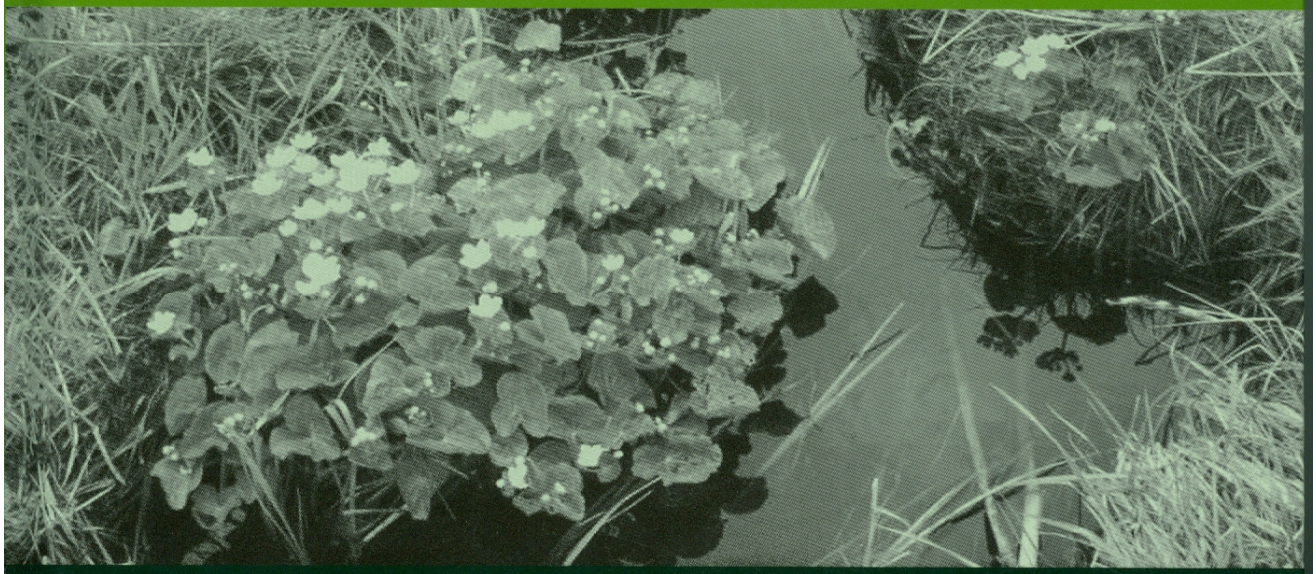
18

INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS SELECTED PAPERS

Editors:
Luís Ribeiro
Tibor Y. Stigter
António Chambel
M. Teresa Condesso de Melo
José Paulo Monteiro
Albino Medeiros

Groundwater and Ecosystems



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Groundwater from mountain bog systems with turf and water acidified by organic acids, Chaloupská Sla, Šumava Mountains, Czech Republic. In relatively flat mountainous areas, and due to the less transmissive media of the underlying crystalline rocks, the water accumulates, forming swamps where bog mountain systems form under the right conditions of recharge (Photo: António Chambel)

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Preface

Recent studies of the Millennium Ecosystem Assessment concluded that over the past five decades the Earth's ecosystems have been rapidly and extensively altered by human activities. This has resulted in a substantial and often irreversible degradation of many of these ecosystems and the essential services they provide. Those depending on groundwater form no exception. Aquifers are facing increasing pressure from water consuming and contaminating activities in various socioeconomic sectors, from industry and agriculture to public supply and recreational activities. This frequently impacts environmental flows that determine the health of groundwater dependent ecosystems (GDEs). Climate change is expected to further contribute to the decrease in groundwater availability, especially in some sensitive regions such as arid and semi-arid areas and coastal and estuarine zones.

This book provides a diverse overview of important studies from across the world, on groundwater-surface water-ecosystem relationships, as well as consequences from human intervention and possible solutions for water resource and environmental management. Among others, the various chapters provide a toolbox for assessing the ecological water requirements for GDEs, relevant case studies on groundwater/surface water ecotones, interactions with vegetation and fauna, as well as the quantitative and qualitative impacts from human activities. The contributions, from Australia (nine studies), Europe (12 studies from nine countries), Argentina, Canada and South Africa, were presented originally at the 35th IAH Congress on Groundwater & Ecosystems, held in Lisbon between 17 and 21 September 2007. They have all been updated by incorporating new results obtained since then. We believe that this book is of interest to anyone dealing with groundwater and its relationship with ecosystems, whether researcher, manager or decision-maker in the field of water and environment, entrepreneur, teacher or student. It provides up-to-date information on crucial factors and parameters that need to be considered when studying groundwater-ecosystem relationships in different environments worldwide. We thank all contributing authors and are truly pleased that together we have managed to bring this challenging endeavour to a successful conclusion.

Luís Ribeiro
Tibor Y. Stigter
António Chambel
M. Teresa Condesso de Melo
José Paulo Monteiro
Albino Medeiros

Foreword

Groundwater provides a vital source of water and creates a critical habitat for a broad range of species. Groundwater dependent ecosystems (GDEs) comprise a complex and often biodiverse subset of the world's ecosystems and can be found in marine, coastal, lotic (river), lentic (lake), terrestrial, cave, and aquifer environments. These are habitats that must have access to groundwater to maintain both their ecological structure and function and are critical components in the conservation of the earth's aquatic biodiversity. GDEs support a disproportionately large number of plants and animals relative to the area they occupy and also offer multiple ecosystem services to humans, such as clean water, fish and wildlife habitat, storm-water control, ethnobotanical uses, cultural values, and sequestration of carbon. Increasingly, the water needs of communities are in direct conflict with the water needs of natural systems. Human activities have the potential to alter the fluxes, levels and quality of groundwater, which, in turn, can diminish groundwater supported biodiversity that has evolved over millennia.

In the human psyche, GDEs are inconvenient places, obstacles to travel and development, friend to neither man nor horse or pick-up truck. They have been saddled with derogatory names like swamp, quagmire, morass, and waterlogged land. They have historically been places to avoid – mosquito infested, full of malaria and deadly vapours. As such, half of the world's wetlands have been obliterated. Many have been ditched and drained for farming; most of the springs have been developed or trampled by livestock; and mangroves are disappearing to coastal development at an alarming rate.

For this reason, a collection of writings about GDEs is a peculiarity. We have been so focused on surface water flows and fisheries, and groundwater hydraulics and contamination, that the interface with GDEs has been a no-man's land for researchers. Sadly, trends in the scientific community have traditionally not been on a broad interdisciplinary view of the world, rather toward ever more specialisation on narrower topics. After all, which biologist is interested in the physics of water flow, and which hydrologist spends time musing over biological questions? Only recently have we acknowledged that surface water and groundwater are linked components of a hydrologic continuum. Fortunately, times are changing and the inner workings of these rich groundwater supported ecotones are being probed by a host of scientific interdisciplinarians, revealing the secrets of these ecologically productive, hydrogeologically unique, and biologically diverse settings.

Despite the importance of groundwater to biodiversity, the precise relationships remain unclear. The challenge for the scientific community is to improve this understanding and help develop effective approaches for protecting groundwater for biodiversity conservation. Convincing water managers that GDEs are valuable ecosystems is one thing. It is still another to answer the inevitable question, 'How much water can we take from the ecosystem before it ceases to function?' The managers' challenge is to balance the intrinsic water needs of nature with the real human need for water so that we all, Man and nature, benefit. The researchers challenge is to define and quantify the key groundwater-ecology relationships and determine ecological thresholds beyond which GDEs of all kinds may experience irreversible degradation.

Read on and take some time to listen to the lessons these natural systems have to tell us. These authors are pioneers and I thank them for their insight, careful observation, and inspiration.

Joseph T. Gurrieri

Director, IAH Groundwater & Ecosystem Network

About the editors

Luís Ribeiro graduated in Mining Engineering at the *Instituto Superior Técnico* (IST) of the Technical University of Lisbon (UTL) in Lisbon (Portugal) in 1978 and completed his PhD in Mining Engineering (Hydrogeology) at IST-UTL in 1992. He is currently Associate Professor at IST, Director of the Geo-Systems Centre/CVRM, and President of the Portuguese Chapter of the International Association of Hydrogeologists (IAH). He was also President of the Scientific Committee of XXXV IAH Congress "Groundwater and Ecosystems" held in Lisbon in 2007.

Tibor Y. Stigter completed his MSc in Geographical Hydrology in 1997 at the *Vrije Universiteit Amsterdam* (The Netherlands) and his PhD in Engineering Sciences (Hydrogeology) in 2005 at the *Instituto Superior Técnico* (IST), Lisbon (Portugal). He has worked and taught classes at the University of the Algarve (UALG) in Faro (Portugal). He currently holds a Researcher position at IST, working on groundwater, contamination, climate change and sustainability. As a member of the Geo-Systems Centre/CVRM, he works both at IST and UALG, co-ordinating research projects and supervising MSc and PhD students.

Born in 1961 in Sardoal, Portugal, **António Chambel** obtained his PhD in Geology, specialising in Hydrogeology, at the University of Évora, Portugal, in 1999. He is currently teacher in the University of Évora and ERASMUS teacher in the Universities of Prague, Czech Republic, and Huelva, Spain, as well as researcher of the Geophysics Centre of Évora. He is Vice-President of Programme and Science Coordination for the International Association of Hydrogeologists and Technical Director of Hydrogeologists Without Borders. He specialises in groundwater prospecting, hydrogeology of hard rocks, relations between groundwater and ecosystems, hydrogeological mapping and aquifer contamination. He has also focussed on legislation and water and environmental management, including the river basin management plans for Portugal.

M. Teresa Condesso de Melo graduated in Geology from the University of Coimbra (Portugal) in 1992, completed her MSc in Groundwater Hydrology at the *Universitat Politècnica de Catalunya* (UPC, Barcelona, Spain) in 1996 and her PhD in Geosciences (Hydrogeology) with a sandwich PhD project at the Hydrogeology Group of the British Geological Survey (BGS, Wallingford, UK) and the University of Aveiro (UA, Aveiro, Portugal) in 2002. In 2006 she became a Guest Professor of hydrogeology at the UA, and she now holds a Researcher position at the *Instituto Superior Técnico* (IST, Lisbon, Portugal).

José Paulo Monteiro currently holds a position as Professor at the University of the Algarve. He obtained his PhD in hydrogeology in 2001 at the Faculty of Sciences of the University of Neuchâtel (Switzerland) and his MSc in hydrogeology in 1993, at the Faculty of Sciences of the University of Lisbon (Portugal). His main research topics are: modelling and monitoring porous, fractured and karstic coastal aquifers, aquifer-ocean and river-aquifer interfaces; hydraulics of water wells; groundwater dependent ecosystems and integrated water resources management.

Albino Medeiros graduated in Applied Economic Geology at the Faculty of Sciences of the University of Lisbon (Portugal) in 1993 and completed his MSc in Engineering Geology, Faculty of Science and Technology, Universidade Nova de Lisboa – UNL (Portugal) in 1999. In 2005 he became a Guest Professor of Groundwater Modelling at the Earth Sciences Department of UNL. Currently he is a hydrogeologist at *Grandewater – Hidrogeologia Aplicada, Lda*, with development work in Portugal and Africa (Angola and Mozambique).

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Groundwater resources are facing increasing pressure from consuming and contaminating activities. There is a growing awareness that the quantitative and qualitative preservation of groundwater resources is a global need, not only to safeguard their future use for public supply and irrigation, but also to protect those ecosystems that depend partially or entirely on groundwater to maintain their species composition and natural ecological processes. Known as groundwater dependent ecosystems (GDEs), they have been a fast-growing field of research during the last two decades.

This book is intended to provide a diverse overview of important studies on groundwater and ecosystems, including a toolbox for assessing the ecological water requirements for GDEs, and relevant case studies on groundwater/surface-water interactions, as well as the role of nutrients in groundwater for GDEs and ecosystem dependence (vegetation and cave fauna) on groundwater. Case studies are from Australia (nine studies) and Europe (12 studies from nine countries) as well as Argentina, Canada and South Africa.

This book is of interest to everybody dealing with groundwater and its relationship with ecosystems. It is highly relevant for researchers, managers and decision-makers in the field of water and environment. It provides up-to-date information on crucial factors and parameters that need to be considered when studying groundwater-ecosystem relationships in different environments worldwide.

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