



# Trends and Sustainability of Groundwater in Highly Stressed Aquifers

Edited by:

MAKOTO TANIGUCHI

ALYSSA DAUSMAN

KEN HOWARD

MAURIZIO POLEMIO

ELANGO LAKSHMANAN

Proceedings of Symposium HS.2 at the Joint Convention of  
the International Association of Hydrological Sciences (IAHS) and  
the International Association of Hydrogeologists (IAH) held in  
Hyderabad, India, 6–12 September 2009.

IAHS Publication 329  
in the IAHS Series of Proceedings and Reports

Published by the International Association of Hydrological Sciences 2009

IAHS Publication 329

ISBN 978-1-907161-00-1

British Library Cataloguing-in-Publication Data.

A catalogue record for this book is available from the British Library.

**© IAHS Press 2009**

*This publication may be reproduced as hard copy, in whole or in part, for educational or nonprofit use, without special permission from the copyright holder, provided acknowledgement of the source is made. No part of this publication may be electronically reproduced, transmitted or stored in a retrieval system, and no use of this publication may be made for electronic publishing, resale or other commercial purposes without specific written permission from IAHS Press.*

The papers included in this volume have been reviewed and some were extensively revised by the Editors, in collaboration with the authors, prior to publication.

IAHS is indebted to the employers of the Editors for the invaluable support and services provided that enabled them to carry out their task effectively and efficiently.

The information, data and formulae provided in this volume are reproduced by IAHS Press in good faith and as finally checked by the author(s); IAHS Press does not guarantee their accuracy, completeness, or fitness for a given purpose. The reader is responsible for taking appropriate professional advice on any hydrological project and IAHS Press does not accept responsibility for the reader's use of the content of this volume. To the fullest extent permitted by the applicable law, IAHS Press shall not be liable for any damages arising out of the use of, or inability to use, the content.

The designations employed and the presentation of material throughout the publication do not imply the expression of any opinion whatsoever on the part of IAHS concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The use of trade, firm, or corporate names in the publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by IAHS of any product or service to the exclusion of others that may be suitable.

Publications in the series of Proceedings and Reports are available from:

**IAHS Press, Centre for Ecology and Hydrology, Wallingford, Oxfordshire OX10 8BB, UK**  
tel.: +44 1491 692442; fax: +44 1491 692448; e-mail: [jilly@iahs.demon.co.uk](mailto:jilly@iahs.demon.co.uk)

Printed in India

## Preface

Population growth, urbanization and global climate change have increased urban and agricultural water demands, stressing aquifer systems where groundwater is a source of water supply. The availability and utility of groundwater may further be threatened by factors stressing the quality of groundwater, such as industrial and domestic wastes and agricultural intensification. Consequences include, for example, over-allocation of groundwater, groundwater overdraft, declining well yields and land subsidence; degraded groundwater quality due to mobilization of natural pollutants (arsenic), salt contamination caused by seawater intrusion; increased demand for conjunctively used surface water, and resulting conflicts with junior users; and streamflow capture and resulting damage to ecosystems. These consequences may occur incrementally and inequitably across an aquifer. Natural environmental problems can further complicate use of groundwater and increase strain on the aquifer system; for example, underground structures, geothermal heating (such as heat islands), and geochemical evolution (such as karst formation, excessive salinity, acidity, fluoride, radioactivity, hardness, or turbidity).

To address this issue, a joint symposium on the *Trends and Sustainability of Groundwater in Highly Stressed Aquifers* was held during the 8th Scientific Assembly of the International Association of Hydrological Sciences, IAHS, and the 37th Congress of the International Association of Hydrogeology, IAH, in Hyderabad, India, September 2009. The symposium was organized by the IAHS International Commission on Groundwater (ICGW), supported IAH and by the IAHS International Commission on Water Quality (ICWQ).

This symposium brought together scientists, including modellers, geochemists and hydrogeologists, with water supply managers and policy makers to discuss scientific and management ideas and approaches for improving the sustainability of highly stressed aquifers. The importance of this topic was reflected in the large number of contributions to the symposium. Selected papers from this symposium have been compiled in this volume.

The editors gratefully acknowledge the assistance of the reviewers who made valuable contributions to this volume. We thank Penny Perrins and Cate Gardner from IAHS Press for their professional approach and help with the processing of the manuscripts.

*Editor-in-Chief*

**Makoto Taniguchi**

*RIHN, Japan, [makoto@chikyu.ac.jp](mailto:makoto@chikyu.ac.jp)*

*Co-Editors*

**Alyssa Dausman (USA)**

*[adausman@usgs.gov](mailto:adausman@usgs.gov)*

**Ken Howard (Canada),**

*[gwater@scar.utoronto.ca](mailto:gwater@scar.utoronto.ca)*

**Maurizio Polemio (Italy)**

*[m.polemio@ba.irpi.cnr.it](mailto:m.polemio@ba.irpi.cnr.it)*

**Elango Lakshmanan (India)**

*[elango@annauniv.edu](mailto:elango@annauniv.edu)*