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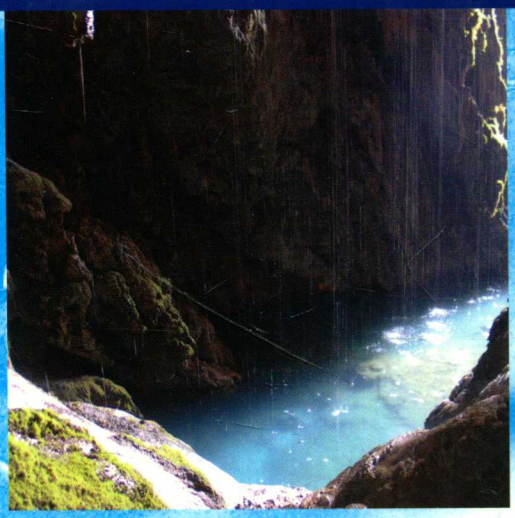

Groundwater Monitoring

Edited by

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Groundwater Monitoring

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Groundwater Monitoring

Water Quality Measurements Series

Series Editor

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Foreword

The assessment and monitoring of groundwater quality has always posed a significant challenge – presenting as it does some special problems. It is by no means a trivial task to know exactly what is going on 'under-our-feet', when it comes to status and trends of the chemical quality of groundwater, bearing in mind that the resource:

- can be distributed over tens to hundreds of metres below ground;
- is characterised by flow regime dynamics with a time-scale ranging from a few years to various millennia;
- will often be threatened by a myriad of potentially polluting activities;
- is normally subject to gradual, often insidious, deterioration under the pressure of contaminant loading from the land surface.

Groundwater quality monitoring has been a neglected aspect of overall environmental surveillance in many countries, both within the European Community (EC) and (even more so) beyond. Despite the major importance of groundwater resources for the economical provision of public water-supply and its key role in sustaining some aquatic ecosystems, many governments have been reluctant to face the significant capital costs and operational logistics associated with dedicated, custom-built, monitoring networks, and have thus placed far too much reliance on the monitoring of drinking water receptors (mainly deep high-yielding water wells). Given the complexity of groundwater flow regimes, such monitoring:

- can be extremely difficult to interpret in terms of identifying and characterising the responsible aquifer pollution processes (and thus specifying remedial and protection measures), because of the major time-lag in the response of deeper groundwater to applied contaminant pressure;
- might be regarded as an 'essentially post-mortem activity' as regards groundwater body protection;
- has often left regulatory agencies uncertain about the seriousness of pollution trends and 'almost blindfold' when it comes to the best approach to protection measures.

The advent of the EC Water Framework Directive (2000) and Groundwater Pollution Protection Directive (2006) is changing all that – since these Directives fully embrace the

need for systematic monitoring and periodic assessment of groundwater quality, for the specification of specific management and protection measures and for their effectiveness to be demonstrated through further appropriate monitoring. Thus the appearance of this book could not be more opportune, since it will serve as a detailed guide for water-sector professionals (be they in environment regulatory agencies or in environmental consultancy firms) on the methodology and practice of groundwater quality assessment and monitoring at the level required by these Directives.

The contributors to this book comprise an impressive list of European authors, from the various scientific disciplines and professional functions necessary for the evaluation and management of groundwater quality, who have pooled their experience from different national hydrogeologic and socioeconomic settings. It has been produced largely under the umbrella of the EC-Directorate General for Environment-Groundwater Working Group, and like that group has greatly benefited from the coordinating vision of Dr Philippe Quevauviller together with sound and consistent leadership from Austrian specialists. It is thus an ideal reference work for those undertaking the important fieldwork that needs to be undertaken on this topic.

Parts 2–4 provide in logical sequence:

- an approach to conceptual modelling of the flow regime of groundwater bodies in terms of aquifer typologies and visualisation and an introduction to groundwater pollution processes;
- the characterisation of groundwater pollutant pressures and behaviour of groundwater contaminants;
- groundwater quality standards (in terms of the identification of 'threshold values') and the evaluation of groundwater chemical status and trends;
- complementary methods and tools for groundwater flow and quality evaluation.

Part 5 provides a very useful set of 'case histories' from seven different European countries – whose intention is to illustrate the basic principles and procedures of groundwater quality assessment and monitoring, as required by the EC Directives and described in the preceding chapters. Part 6 then gives an overview of groundwater measurements aspects. The book concludes by providing an insight into stakeholder's involvement in teaching, networking and communication features.

This book is firmly based in sound science, richly illustrated and practically oriented. It will be of considerable interest and direct relevance to all those in the EC and beyond confronted with the challenge of designing and operating programmes of groundwater quality evaluation and pollution protection.

Prof. Dr Stephen Foster[1]
February 2009

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Series Preface

Water is a fundamental constituent of life and is essential to a wide range of economic activities. It is also a limited resource, as we are frequently reminded by the tragic effects of drought in certain parts of the world. Even in areas with high precipitation, and in major river basins, over-use and mismanagement of water have created severe constraints on availability. Such problems are widespread and will be made more acute by the accelerating demand on freshwater arising from trends in economic development.

Despite of the fact that water-resource management is essentially a local, river-basin based activity, there are a number of areas of action that are relevant to all or significant parts of the European Union and for which it is advisable to pool efforts for the purpose of understanding relevant phenomena (e.g. pollutions, geochemical studies), developing technical solutions and/or defining management procedures. One of the keys for successful cooperation aimed at studying hydrology, water monitoring, biological activities, etc. is to achieve and ensure good water quality measurements.

Quality measurements are essential to demonstrate the comparability of data obtained worldwide and they form the basis for correct decisions related to management of water resources, monitoring issues, biological quality, etc. Besides the necessary quality control tools developed for various types of physical, chemical and biological measurements, there is a strong need for education and training related to water quality measurements. This need has been recognised by the European Commission which has funded a series of training courses on this topic, covering aspects such as monitoring and measurements of lake recipients, measurements of heavy metals and organic compounds in drinking and surface water, use of biotic indexes, and methods to analyse algae, protozoa and helminths. In addition, series of research and development projects have been or are being developed.

This book series ensures – and will continue to do so – a wide coverage of issues related to water quality measurements, including the topics of the above mentioned courses and the outcome of recent scientific advances. In addition, other aspects related to quality control tools (e.g. certified reference materials for the quality control of water analysis) and monitoring of various types of waters (river, wastewater, groundwater, seawater) are being considered.

Groundwater Monitoring is the ninth of the series; it has been written by policy-makers and scientific experts in issues related to monitoring groundwater as requested by the

Water Framework Directive and its daughter Groundwater Directive. It offers the reader an overview of technical issues related to groundwater quality assessment and monitoring, as well as case studies illustrating them.

Ph. Quevauviller
Series Editor

Preface

Groundwater is sometimes called 'the hidden asset' – awareness of its existence and its importance is not well known and as a consequence the measures which are required to protect and manage it in an environmental sustainable way are either not taken or are taken too late. Where pollution has occurred and measures are taken too late it may take decades, or longer, until the necessary restoration of quality is achieved. This is due to the slow movement of groundwater (and pollutants) through the ground and the very long residence times. Groundwater is the most abundant source of readily available freshwater in the world making up 97% of all freshwater (excluding glaciers and polar caps). In early times it was thought that the soils and rocks overlying groundwater bodies would provide sufficient protection to groundwater. However, groundwater monitoring, scientific research and investigation have shown that pollutants can penetrate the soil and the unsaturated zone and enter groundwater.

Groundwater protection is covered by several EU Directives covering agricultural and other pressures, which are operated under a common regulatory umbrella, namely the Water Framework Directive (EC 2000/60/EC) and its associated daughter Groundwater Directive (2006/118/EC). It is also considered in the framework of international conventions. In parallel with the establishment of groundwater-related legislation, efforts have been made to better understand groundwater systems, their relationship to other parts of the water environment and the process that control the fate and transport of pollutants. Hydrogeological systems across the world differ greatly due to the complex geological, environmental and climatic variations. They can be extremely complex to understand and hence, the characterisation and assessment of aquifer systems and groundwater bodies can be a very time-consuming process. Improved monitoring is playing a very important role in this by establishing the evidence base to support groundwater protection and management.

The Water Framework Directive imposes EU Member States to undertake wide-scale monitoring programmes for all waters in order to develop river basin management plans and programmes of measures aiming to achieve 'good status' objectives by 2015. With respect to groundwater, these obligations concern chemical and quantitative status objectives. The directive introduces specific requirements in this context, which are often prone to various interpretations. The policy-making and scientific communities, along with industrial stakeholders and NGOs have recognised this and have worked altogether to develop guidance documents reflecting common understanding in relation to the development of the Groundwater Directive, which paves the way for new groundwater quality assessment for the forthcoming decade. This will generate a wide array of collaborations among R&D and policy communities, training activities, educational materials, etc. This

book is all about these on-going features. It is very timely in that it is published while the WFD groundwater monitoring programme is fully operational, anticipating a review of monitoring and assessment methods planned in 2012.

The four editors have been striving to collect state-of-the-art information on groundwater quality assessment monitoring from the international groundwater community, providing further stimulation to the work of all parties involved in the huge challenges on the way to a ensure a sound quality assessment of groundwater.

Philippe Quevauviller, Anne-Marie Fouillac, Johannes Grath and Rob Ward

The Series Editor – Philippe Quevauviller

Philippe Quevauviller began his research activities in 1983 at the University of Bordeaux I, France, studying lake geochemistry. Between 1984 and 1987 he was Associate Researcher at the Portuguese Environment State Secretary where he performed a multidisciplinary study (sedimentology, geomorphology and geochemistry) of the coastal environment of the Galé coastline and of the Sado Estuary, which was the topic of his PhD degree in oceanography gained in 1987 (at the University of Bordeaux I). In 1988, he became Associate Researcher in the framework of a contract between the University of Bordeaux I and the Dutch Ministry for Public Works (Rijskwaterstaat), in which he investigated organotin contamination levels of Dutch coastal environments and waterways. From this research work, he gained another PhD in chemistry at the University of Bordeaux I in 1990. From 1989 to 2002, he worked at the European Commission (DG Research) in Brussels where he managed various Research and Technological Development (RTD) projects in the field of quality assurance and analytical method development for environmental analyses in the framework of the Standards, Measurements and Testing Programme. In 1999, he obtained an HDR (Diplôme d'Habilitation à Diriger des Recherches) in chemistry at the University of Pau, France, from a study of the quality assurance of chemical species' determination in the environment.

In 2002, he left the research world to move to the policy sector at the EC Environment Directorate-General where he developed a new EU Directive on groundwater protection against pollution and chaired European science-policy expert groups on groundwater and chemical monitoring in support of the implementation of the EU Water Framework Directive. Since 2008, he has been at the EC DG Research where he is managing research projects on climate change impacts on the aquatic environment, while ensuring strong links with policy networks.

Philippe Quevauviller has published (as author and co-author) more than 220 scientific and policy publications, 80 reports and 6 books for the European Commission and has acted as an editor and co-editor for 22 special issues of scientific journals and 10 books. Finally, he is Associate Professor at the Free University of Brussels and promoter of Master theses in an international Master on water engineering (IUPWARE programme), and he also teaches integrated water management issues and their links to EU water science and policies to Master students at the Universities of Paris 7, Polytech'Lille and Polytech'Nice (France).

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