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Editorial

Urban Hydrogeology Studies

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1. Introduction

Urbanization is a pervasive phenomenon of our time, and sustainable urban development is one of the greatest challenges faced by the contemporary world. The subsurface plays a range of roles in such developments through the complex processes of urbanization, including building developments, constructing roads, providing water-supply, drainage, sanitation and even solid-waste disposal.

For most cities, the groundwater system represents a 'linking component' between various elements of the urban infrastructure. Since urban processes have an influence on groundwater and groundwater conditions have an impact on the urban infrastructure, groundwater systems thus exhibit a close relationship with the processes of urbanization, and this continuously changes with the urban development cycle. Consequently, cities around the world face issues related to urban hydrogeology, requiring attention at least as much as those provided by other planning-related problems in urban areas.

Urban groundwater problems are usually predictable. However, they are not predicted early enough, as action usually responds to emergencies rather than to planning. Consequences resulting from a lack of accurate and detailed knowledge of the underground environment and the interaction between the urban groundwater and urban infrastructure are faced by cities across the entire world in economic, environmental, social, legal and political terms.

The lack of data and planning, as well as poor communication between the scientific community and city managers, exacerbate the difficulties of solving urban hydrogeology problems. To provide the necessary understanding, experts have to use robust datasets of urban fabric, infrastructure networks, groundwater and geothermal energy systems at the city scale. Furthermore, this knowledge and understanding must also be accessible to urban planning processes.

In recent decades, progressive advances in the scientific understanding of urban hydrogeological processes and the groundwater regimes of a substantial number of cities have been documented. This extensive array of subsurface challenges which cities have to contend with lies at the core of the sustainability of the urban water cycle. This is threatened by the increasing scale and downward extent of urban subsurface construction, including utilities (cables, sewage, drainage), transportation (tunnels, passages) and storage (cellars, parking lots, thermal energy). The cumulative impact of this subsurface congestion on the surrounding geology, and especially the groundwater system, has to be constantly studied and addressed.

In this volume, key connections amongst the urban hydrogeology activities are identified consistent with scientific results and good practices in relationship to subsurface data and knowledge of sub-surface systems. The volume supports a useful dialogue between the providers and consumers of urban groundwater data and knowledge offering new perspectives on the existing research themes.

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2. Summary of This Special Issue

The opening article [1] defines a context for policy development and proposes steps for integrating groundwater into the urban water and land management context. On the basis of a strategic assessment of the major trends perceived in 10 world spread developing cities, Professor Stephen Foster analyzes the benefits both to water users and to the broader community of groundwater use. Associated risks considering resource sustainability, built infrastructure, public-health hazards and the economic distortion of water-sector investments are evidenced. This is developed further in the article of Mielby and Henriksen [2] that outlines the crucial need of using cross-disciplinary methodologies to develop adaptive design and resilience in urban planning and management. On the basis of several hydrogeological studies performed in Odense, Denmark, the authors identify needed improvements in standardized data and modelling to promote strategic planning and decision making in order to diminish the environmental consequences of city infrastructure developments.

The main directions of the current research worldwide in urban hydrogeology are well balanced in this Special Issue. Three papers [3–5] describe different research experiences in quantitative urban groundwater studies with case studies in Detroit, USA, and Nantes, France, the third one being a laboratory study. The qualitative urban groundwater nucleus of this volume is represented by three other papers of three distinct cases studies that describe distinct groundwater contamination problems. These are located in Ljubljana, Slovenia [6]; North Carolina, USA [7]; and Belgium [8].

A study [3] in the Great Lakes Basin in Detroit, USA, provides an improved understanding of urban groundwater focusing on two approaches: the regional and local areas. A regional groundwater model that encompasses four major watersheds has been defined to outline the large-scale groundwater characteristics. On this basis, the local-scale model has been developed to analyze the local urban water budget with subsequent groundwater simulation. Both regional- and local-scale models can be further used to evaluate and mitigate urban environmental risks.

Using experimental data recorded on a small urban catchment, a model has been built to simulate the groundwater seepage into the sewer network in Nantes, France [4]. The experimental analysis revealed a strong correlation between groundwater levels and sewer base flow. The authors mentioned that the total groundwater volume drained by the sewer system represents 42% of the total rainfall annually.

The third [5] article focuses on the effects of artificial groundwater barriers made of cutoff walls. The authors underline the necessity of building effective, strong, flexible and low-permeability cutoff walls. Their study proposes a methodology to choose optimum construction materials. Based on laboratory results, their approach focuses on assessing the viscosity and representation of the Water–Cement–Bentonite components and presents an improved method for materials composition.

Ljubljana, the capital of Slovenia, considered the greenest city of the world, is the chosen study area [6] to model groundwater nitrogen loads coming from agriculture and leaky sewer system. The estimated total nitrogen load has been used to simulate the distribution of nitrate concentration into the aquifer using a groundwater contaminant transport model. The model, quantifying the impact of pressures from different contamination sources, can be further used in groundwater quality management activities.

In cold urban environments, unplanned natural raised wetlands represent one solution to reduce the impact of road salt contamination in surface water and groundwater. A study [7] was conducted in northwestern North Carolina, USA, on the capacity to control the timings and reduce peak concentrations of road salt into a stream of an accidental raised wetland. The study, based on the modelling of multiple meltwater and summer storm event scenarios, indicates that accidental wetlands improve stream water quality, and they may also reduce peak temperatures during temperature surges in urban streams.

Abandoned industrial sites represent a strong environmental threat in many areas worldwide. A study case [8] has been developed in Belgium to investigate the hydrochemical processes controlling groundwater mineralization through the characterization of the backfill and groundwater chemical composition. The analysis focuses on groundwater pollution, due to a mixture of chlorinated solvents with mainly 1,1,1-trichloroethane (1,1,1-TCA) at high concentrations.

Nowadays, remote sensing techniques are increasingly used to identify subsidence due to groundwater overexploitation. The volume also has a paper dedicated to the monitoring and modelling of subsidence as consequence of groundwater overexploitation in Semarang City, the capital of Indonesia [9]. A study integrating numerical modeling and synthetic aperture radar interferometry (InSAR) is presented. The models, simulating the hydromechanical coupling of groundwater flow and land subsidence, describe groundwater management measures to reduce the rate and affected area of subsidence.

Green infrastructure is one of the most important responses to urbanization, and a large-scale study based on a set of infiltration experiments [10] carried out in three swales completes this volume. In Holland, in the municipality of Dalfsen, a research project analyzed infiltration rate variation under extreme climate events. The study contributes to a better understanding of infiltration processes in this type of drainage system.

Urban planning should consider both above-ground and underground infrastructure development, including accurate groundwater management. Radutu et al. [11] highlight the need for accurate studies to properly discriminate the phenomena and processes generating subsidence. Satellite remote sensing used with a methodology characterizing the study area, demonstrates a major concordance between the groundwater level and the vertical displacements. With the purpose of understanding the connection between the cities' development and urban groundwater, the article reviews the urban plans in Romania, analyzes the strategic and planning framework of Bucharest city and discerns the role of groundwater as one of the main subsidence-triggering factors.

The future of our cities will increasingly need to rely on the sustainable use and reliable management of urban groundwater. This volume addresses this for groundwater and geotechnical specialists, civil engineers, infrastructure developers, land-use planners and geodetic experts. In addition, city managers and experts involved with various sectors of municipal utilities and environmental departments could use this Special Issue to improve their understanding of urban hydrogeology as a basis for accurate subsurface management.

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