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Hydrolink

GROUNDWATER AND ITS MANAGEMENT AS CRITICAL COMPONENTS OF SUSTAINABLE DEVELOPMENT

BY ZHONGBO YU, ALBERTO GUADAGNINI & DANIELE TONINA

Groundwater is a key component of the hydrologic cycle. The documented increasing scarcity of fresh water and the degradation of its quality place groundwater resources under pressure. Monitoring groundwater dynamics and improving the ability to interpret groundwater processes is a critical challenge for transformative practices in water resources management. Feedbacks between global drivers, such as climate change, and anthropogenic actions, including population dynamics, tend to affect hydrological systems on multiple spatial and temporal scales. Water security in a rapidly changing environment is a critical issue attracting international attention. The United Nations Agenda 2030 for Sustainable Development addresses three aspects on sustainable development, i.e., society, economy and environment. Many countries currently face major challenges in the implementation of national water security strategies and in their effort to achieve sustainable development at a time of intensive environmental changes. To fully assess the consequences posed on water resources by climate change, society and technological progress, requires profound understanding of a variety of processes and the ability to properly interpret signals embedded in the available data. Examples include contamination processes, potential risks linked with conventional or unconventional energy sources, excessive water drawdown, the effect of droughts, or groundwater-related feedbacks from flooding events in urban environments.

In broad terms, groundwater hydraulics is concerned with the analysis of flow and transport processes in porous and fractured geologic formations. Water management and its effect on the environment are main topics of concern. Groundwater possibly constitutes the most valuable freshwater resource on Earth, representing a resource which is as much as two orders of magnitude larger than the total water volume associated with rivers and lakes.

Groundwater systems vary greatly, depending on their geological signature, e.g. sand and gravel aquifers, fissured rock aquifers, karstic aquifers). The hydraulic behavior of such systems is characterized by large water volumes and generally low flow velocities, typically resulting in markedly long residence and exchange times. Transport at regional scales is affected by heterogeneities of the geological formations, in terms of the spatial architecture of hydrofacies and their attributes, which still poses significant challenges to modeling and providing risk-based decision metrics. Bio-geo-chemical reactions take place at the pore scale and their effects propagate to a variety of spatial and temporal scales. Key drivers of groundwater recharge include rainfall, infiltration and the interaction with surface waters, and involve a variety of processes in variably saturated soil environments.

The protection of groundwater quality is a major environmental issue in most countries. Instances of groundwater pollution by diffuse or concentrated sources, resulting from accidental or poorly planned activities at the ground surface, are quite common. Industrial, domestic and agricultural contamination sources include waste disposal sites, accidental spills, leaking septic tanks, fertilizers, herbicides and pesticides. Air pollution contributes to groundwater pollution via atmospheric the deposition of contaminants at the ground surface that eventually make their way into the groundwater. Contaminants which are not miscible with water can also be found in the subsurface as a non-aqueous phase, as well as dissolved in the water, or adsorbed onto the solid phase.

Research agenda: The IAHR Groundwater Hydraulics and Management Committee serves as a platform for interested parties around the world to share their vision on research as well their approaches to addressing challenges in groundwater-related environmental and societal needs. Activities promoted by the IAHR Groundwater Hydraulics and Management Committee include studies on a variety of subsurface processes, remediation and water management. Problems in these subjects are tackled in an integrated way within an operational framework for risk assessment under uncertainty. This work directly supports SDG 2 (food production) as groundwater is a major source of irrigation around the world; SDG 3 (public health) by developing methods to identify, contain, remediate and prevent ground-

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water contamination; and SDG 6 (water, and sanitation) by helping development of drinking water sources and ensuring that the use of proper sanitation prevents the the pollution of groundwater. The work of members of the Committee has also implications for the development of policies and best practices for sustainability of cities and communities (SDG 11) as well as for responsible consumption and production (SGD 12). In this broad context, effective monitoring of aquifer bodies should include appropriate design of future monitoring networks and sampling frequency of target environmental variables to increase certainty and maximize the value of collected data. Adoption of goal-oriented monitoring practices can allow early recognition of chemical plumes and biological activities. It can also enhance the effectiveness of timely countermeasures as well as provide fundamental data to advance our ability to represent the subsurface environment through models with diverse degrees of fidelity. Studies on flow and transport of partially saturated regions, which are also part of critical zones where there is a delicate feedback between anthropogenic and geogenic components, provide fundamental understanding of the subsurface processes and their interaction with surface water and ecobiological systems. Restoring water quality in polluted aquifers involves clean-up operations in the saturated and unsaturated regions. major issues of concern in the context of integrated groundwater management include aquifer overexploitation, changing groundwater levels, water deficits, and soil and water pollution. Risks associated with groundwater pollution are ubiquitous and their assessment should always take into account uncertainty. These risks must be recognized and properly addressed, managed, and communicated. In this context, the evaluation and effective design and implementation of sustainable water resources policies remain important topics for groundwater management. Dealing with them requires continuous improvement of our ability to assess the vulnerability of groundwater resources. Studies on coupled flow, transport and bio-geo-chemical processes along with proper accounting for the spatial variability properties and processes, and the way information content can be transferred across scales remain fertile research topics.

What lies ahead: the IAHR Groundwater Hydraulic and Management Committee has promoted and supported the organization of a series of international groundwater symposia, including a major event planned for Water Security and Sustainability conference in Nanjing, China in 2018. This conference will be a forum where scientists and stakeholders from the industry and public administration will have the opportunity to share their recent research and application-oriented results and vision, to discuss and promote strategies for addressing global change challenges. The major theme of the conference will focus on "Global Change Challenges: Water Security and Sustainability" with six focused topics on hydrologic processes, modeling, groundwater protection, new approaches for monitoring, sustainability of water

THE FLUID MECHANICS COMMITTEE AND THE SDGs

The focus of the Fluid Mechanics Committee is on fundamental and applied environmental fluid mechanics in support of hydraulic research. Particular emphasis is on the fundamentals of transport and mixing phenomena in turbulent flows such as contaminant transport processes in rivers, lakes and coastal regions, anthropogenic influences (e.g., heat, dissolved and suspended organic/inorganic material) and sediment dynamics.

The activities of the committee are summarized in its website (https://www.iahr.org/site/cms/contentviewarticle.asp?article=646).

Mostly the committee's involvement in these topics comes from hosting summer schools, workshops and symposia that cut across above topics. For example, its educational mission is largely covered by the Gerhard Jirka Summer School, which is rotated around the globe at various international destinations. The Jirka School emphasizes theory, experiments and applications, with focus on basic theoretical principles (and their mathematical description), as well as consideration of examples of engineering design and environmental applications. Formal in-class lectures as well as informal out of class excursions and visits are part of the school. This approach represents the vision of the committee to help develop fundamental understanding on fluid processes (air and water), as well as the interaction of fluids with natural, factitious and biological elements. Climate change and how it affects water resources, run off, urban heat island, natural disasters, green infrastructure, air pollution and human health are addressed in various conferences, and in some cases the conference themes or special sessions are dedicated to this purpose. Sustainable development is considered in the framework on development through a thematic area called Urban Fluid Mechanics. The fluid mechanics committee hosts four regular conferences: the International Symposium on Environmental Hydraulics (ISEH), Stratified Flows (ISSF), and Shallow Flows (ISSF) and supports two symposia, Ultrasonic Doppler Methods (ISUD) and Hydrodynamics (ICHD). The committee hopes to initiate a workshop series dedicated to the sustainable development of cities.

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The fluid mechanics committee contributes to the sustainable development goals of clean water and sanitation (SDG 6), affordable and clean energy (SDG 7), industry and infrastructure (SDG 9), sustainable cities and communities (SDG 11), climate change (SDG 13) and quality education (SDG 4) ■