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Editorial: Groundwater systems worldwide

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Editorial on the Research Topic
Groundwater systems worldwide

Groundwater, with a total volume of 23.4 × 10^6 km^3, represents 30% of the world's freshwater or 2.5% of the total global water storage. Thus, it is an important area of research and a valuable resource for humankind (Oki and Kanae, 2006). Groundwater is an essential component of the global hydrological and biogeochemical cycles and plays a major role in ecosystems sustainability (Zektser and Loaiciga, 1993; Jackson et al., 2001; Sophocleous, 2002; Griebler and Avramov, 2015; Frappart et al., 2019). Similarly, groundwater is an essential water resource for meeting various human needs, including domestic water supply, irrigation and industrial operations. Groundwater is often the last freshwater resource available for domestic use and irrigation once surface waters are depleted, especially in semi-arid areas and densely populated countries (Giordano, 2009; Siebert et al., 2010). In many regions of the world, aquifers are the largest and safest drinking water supply (Doveri et al., 2015).

Groundwater storage and flows are increasingly affected by human activities (Zektser and Everett, 2004; Shah, 2007) and climatic stresses (Döll, 2009; Green et al., 2011; Taylor et al., 2013). This may have negative consequences both for the functioning of the terrestrial environment and ecosystems as well as water supply for large populations due to the depletion of groundwater levels in many regions around the world. A depletion of 4,500 km^3 was estimated worldwide between 1900 and 2008 (Konikow, 2011). Despite this global groundwater crisis (Famiglietti, 2014), groundwater is either poorly monitored or not monitored in many regions of the world (Jones, 2011). Thus, there is an urgent need to understand the properties and behaviour of groundwater systems around the world to support sustainable water resources managment. The authors in this Research Topic provided original contributions on two broader topics: i) modelling and mapping of groundwater systems; and ii) impact of natural and anthropogenic stresses on groundwater supply.

Kaewdum and Chotpantarat analyzed groundwater recharge potential in the lower Khwae Hanuman sub-basin in Thailand based on geological and hydrogeological features. This region anually faces water shortage during the dry season and groundwater is used as an additional freshwater source, especially for irrigation purposes. Using a weighted overlay analysis through geographic information system, the authors found that only less than 13% of the rainfall in the study area contributes to the aquifer recharge; whereas the rest of the rainfall is lost to either evapotranspiration or surface runoff. Additionally, only a small part of the sub-basin (2.26% of the 1,500 km^2 of its area) is identified to have a high recharge potential, which is mostly affected by the lightology in the region.

Groundwater resources have been overexploited for many years in the Choushui River alluvial fan in Central Taiwan (~2,000 km^2). By conducting a trend analysis, Yeh et al. found that the groundwater levels in the Choushui River alluvial fan have significantly declined from 1999 to 2019. By applying the geographic weighted regression approach, the authors report that groundwater levels in the study area are impacted by drainage density, slope, normalized difference vegetation index (NDVI), and rainfall during the dry season, and by drainage density, slope, NDVI, and wetness index (WI) during the wet season.

Many coastal areas worldwide are experiencing freshwater shortages due to their overexploitation and saltwater intrusion. Unconsolidated coastal groundwater systems are generally heterogenous due to a succession of numerous layers of highly permeable aquifers with nearly impermeable aquitards. Fresh groundwater volume and its salinity distribution are controlled by this heterogeneity. To estimate the volumes of freshwater contained in these inland and offshore coastline aquifers, (Zamrsky et al.), quantified the geological heterogeneity of coastal unconsolidated groundwater systems formed during the last 1 Ma by combining conceptual geological models. They modeled changes in groundwater salinities and offshore fresh groundwater volume during a full glacial–interglacial cycle (the last 0.13 Ma) to take into account sea-level fluctuations that cause changes in coastline as well as salinity incursions.

Global warming can also lead to rise in aquifer temperatures. Using field measurements of aquifer temperature from early 1009s and 2019 for Bavaria in Germany, Hemmerle and Bayer found a moderate to good correlation between the trends in air and groundwater temperatures. This correlation was found to be influenced by the depth and local hydroclimatological conditions for the 32 study wells. The increase in air temperature of 0.35 K $(10a)^{-1}$ between 1990 and 2019 caused a corresponding increase of 0.28 K $(10a)^{-1}$ and 0.09 K $(10a)^{-1}$ in groundwater at 20 and 60 m depth, respectively.

Climate change and anthropogenic activities are major threats for surface and groundwater security. (Birhanu et al.) analyzed the impacts of natural and anthropogenic stresses on surface and groundwater supply sources in the Upper Awash Sub-Basin, Ethiopia, which supplies water to the capital city of Addis Ababa. The impacts of population growth, leakage, expansion of surface and groundwater supply schemes for several climate change scenarios were simulated up to 2030. Under the assumption of high population growth rate, the unmet domestic water demand for Adis Ababa may reach 760 Mm^3 in 2030, of which 23% is due to water leakage through water supply distribution networks. Projected groundwater levels could decline by more than 20 m due to increase in the abstraction. The effect of climate change, even considering low rainfall, is not significant compared to anthropogenic pressure and poor quality of water supply network.

Overall, this special issue presents a cross section of current research topics from around the world which contribute to improved understanding of groundwater condition and management, through statistical and deterministic modeling and mapping, under current or future climate.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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