



HAL
open science

Editorial: Groundwater systems worldwide

Frédéric Frappart, Venkatesh M Merwade

► **To cite this version:**

Frédéric Frappart, Venkatesh M Merwade. Editorial: Groundwater systems worldwide. *Frontiers in Earth Science*, 2022, 10, 10.3389/feart.2022.1097789 . hal-04056280

HAL Id: hal-04056280

<https://hal.inrae.fr/hal-04056280v1>

Submitted on 3 Apr 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License



OPEN ACCESS

EDITED AND REVIEWED BY

Wouter Buytaert,
Imperial College London,
United Kingdom

*CORRESPONDENCE

Frédéric Frappart,
✉ frederic.frappart@inrae.fr
Venkatesh M. Merwade,
✉ vmerwade@purdue.edu

SPECIALTY SECTION

This article was submitted to
Hydrosphere,
a section of the journal
Frontiers in Earth Science

RECEIVED 14 November 2022

ACCEPTED 30 November 2022

PUBLISHED 08 December 2022

CITATION

Frappart F and Merwade VM (2022),
Editorial: Groundwater
systems worldwide.
Front. Earth Sci. 10:1097789.
doi: 10.3389/feart.2022.1097789

COPYRIGHT

© 2022 Frappart and Merwade. This is an
open-access article distributed under
the terms of the [Creative Commons
Attribution License \(CC BY\)](#). The use,
distribution or reproduction in other
forums is permitted, provided the
original author(s) and the copyright
owner(s) are credited and that the
original publication in this journal is
cited, in accordance with accepted
academic practice. No use, distribution
or reproduction is permitted which does
not comply with these terms.

Editorial: Groundwater systems worldwide

Frédéric Frappart^{1*} and Venkatesh M. Merwade^{2*}

¹INRAE, Bordeaux Sciences Agro, UMR1391 ISPA, Villenave d'Ornon, France, ²Lyles School of Civil Engineering, Purdue University, West Lafayette, IN, United States

KEYWORDS

groundwater, aquifers and aquifer systems, climate change, anthropogenic impact, recharge, depletion

Editorial on the Research Topic Groundwater systems worldwide

Groundwater, with a total volume of $23.4 \times 10^6 \text{ km}^3$, 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 $4,500 \text{ km}^3$ 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 management. 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 Chotpantararat analyzed groundwater recharge potential in the lower Khwae Hanuman sub-basin in Thailand based on geological and hydrogeological features. This region annually 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 km² of its area) is identified to have a high recharge potential, which is mostly affected by the lithology in the region.

Groundwater resources have been overexploited for many years in the Choushui River alluvial fan in Central Taiwan (~2,000 km²). 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 heterogeneous 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.)

References

- Döll, P. (2009). Vulnerability to the impact of climate change on renewable groundwater resources: A global-scale assessment. *Environ. Res. Lett.* 4, 035006. doi:10.1088/1748-9326/4/3/035006
- Doveri, M., Menichini, M., and Scozzari, A. (2015). "Protection of groundwater resources: Worldwide regulations and scientific approaches," *Threats to the Quality of Groundwater Resources*, Springer, New York, NY, USA, 1–18. doi:10.1007/698_2015_421

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 Addis Ababa may reach 760 Mm³ 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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

- Famiglietti, J. S. (2014). The global groundwater crisis. *Nat. Clim. Chang.* 4, 945–948. doi:10.1038/nclimate2425

- Frappart, F., Papa, F., Güntner, A., Tomasella, J., Pfeffer, J., Ramillien, G., et al. (2019). The spatio-temporal variability of groundwater storage in the Amazon River Basin. *Adv. Water Resour.* 124, 41–52. doi:10.1016/j.advwatres.2018.12.005

- Giordano, M. (2009). Global groundwater? Issues and solutions. *Annu. Rev. Environ. Resour.* 34, 153–178. doi:10.1146/annurev.enviro.030308.100251
- Green, T. R., Taniguchi, M., Kooi, H., Gurdak, J. J., Allen, D. M., Hiscock, K. M., et al. (2011). Beneath the surface of global change: Impacts of climate change on groundwater. *J. Hydrology* 405, 532–560. doi:10.1016/j.jhydrol.2011.05.002
- Griebler, C., and Avramov, M. (2015). Groundwater ecosystem services: A review. *Freshw. Sci.* 34, 355–367. doi:10.1086/679903
- Jackson, R. B., Carpenter, S. R., Dahm, C. N., McKnight, D. M., Naiman, R. J., Postel, S. L., et al. (2001). Water in a changing world. *Ecol. Appl.* 11, 1027–1045. doi:10.1890/1051-0761(2001)011[1027:wiacw]2.0.co;2
- Jones, J. A. A. (2011). “Groundwater in peril,” in *Sustaining groundwater resources: A critical Element in the global water crisis international year of planet Earth*. Editor J. A. A. Jones (Netherlands, Europe: Springer Netherlands), 1–19. doi:10.1007/978-90-481-3426-7_1
- Konikow, L. F. (2011). Contribution of global groundwater depletion since 1900 to sea-level rise. *Geophys. Res. Lett.* 38. doi:10.1029/2011GL048604
- Okii, T., and Kanae, S. (2006). Global hydrological cycles and world water resources. *Sci. (New York, N.Y.)* 313, 1068–1072. doi:10.1126/science.1128845
- Shah, T. (2007). “10_Groundwater: A global assessment of scale and significance,” in *Water for food, Water for life: A comprehensive Assessment of water Management in agriculture*, 395–423. Earthscan, Oxfordshire, UK, <https://cgspage.cgiar.org/handle/10568/36890>.
- Siebert, S., Burke, J., Faures, J. M., Frenken, K., Hoogeveen, J., Döll, P., et al. (2010). Groundwater use for irrigation – A global inventory. *Hydrol. Earth Syst. Sci.* 14, 1863–1880. doi:10.5194/hess-14-1863-2010
- Sophocleous, M. (2002). Interactions between groundwater and surface water: The state of the science. *Hydrogeology J.* 10, 52–67. doi:10.1007/s10040-001-0170-8
- Taylor, R. G., Scanlon, B., Döll, P., Rodell, M., van Beek, R., Wada, Y., et al. (2013). Ground water and climate change. *Nat. Clim. Chang.* 3, 322–329. doi:10.1038/nclimate1744
- Zektser, I. S., and Everett, L. G. (2004). Groundwater resources of the world: And their use. https://openlibrary.org/books/OL12950972M/Groundwater_Resources_of_the_World_and_Their_Use.
- Zektser, I. S., and Loaiciga, H. A. (1993). Groundwater fluxes in the global hydrologic cycle: Past, present and future. *J. Hydrology* 144, 405–427. doi:10.1016/0022-1694(93)90182-9