

EDITORIAL MESSAGE**Groundwater in the cities of Europe: hidden challenges in a changing climate**

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In European cities, groundwater remains an issue of significant concern, largely because it is “out of sight and out of mind.” The general public, and even decision-makers, possess only a limited understanding of the state and characteristics of this vital resource. As a consequence, problems related to groundwater quality or changing water tables/piezometric surfaces may persist for years, or even decades, without being adequately addressed—or worse, without being noticed at all before resulting in land subsidence, saltwater intrusion, deep migration of persistent organic contaminants like PFAS (Le monde, 2023) or other irreversible consequences. The urban water cycle is central to ensuring the supply of clean, safe drinking water, effective sanitation, and well-functioning drainage systems for millions of residents. The impacts of human activities, such as land use change, excessive water abstraction and mismanagement, and the discharge of wastewater can exert a far greater influence on groundwater systems and hydrogeology than climate change. These activities alter the quantity and quality of both surface and groundwater, raising complex scientific, technical, socio-economic, cultural, and ethical challenges in urban water management. It is important to address the many challenges associated with ensuring water security and safety in cities (Quevauviller et al., this volume), as well as for development of effective climate change mitigation and adaptation strategies for urban areas (IPCC, 2024). Groundwater plays a critical role in the green transition and is an integral component of most climate change mitigation and adaptation strategies (Ingemarsson et al., 2022), and for meeting the increasing demand for freshwater in cities due to accelerating urbanization (United Nations, 2022). Many urbanized areas in Europe already face poor chemical and quantitative status (EEA, 2024; Sentek et al., 2024), and global change including increasing populations and sea level rise pose a tremendous challenge for safe and secure water supply especially in coastal European cities. Open access to digital subsurface data e.g. through the European Geological Data Infrastructure supports societal needs and UN sustainable development goals (Hinsby et al., 2024). This special issue demonstrates some of the important issues that the water supply of European cities are facing in times of increasing competing use of the subsurface (Volckko et al., 2020), projected climate change impacts on the hydrological cycle (Henriksen et al., 2023) and with freshwater now being among the transgressed planetary boundaries (Richardsson et al., 2023).

This special issue is the product of a collaborative effort between the Urban Geology and Water Resources Expert Groups (UGEG and WREG) of EuroGeoSurveys, the organisation representing the geological surveys of Europe. It offers a comprehensive overview of the state of knowledge regarding groundwater in some urbanised areas across the continent. Moreover, the analysed cities have been associated to the “groundwater city categories” according to the classification system proposed by La Vigna (2022) (Fig.1).

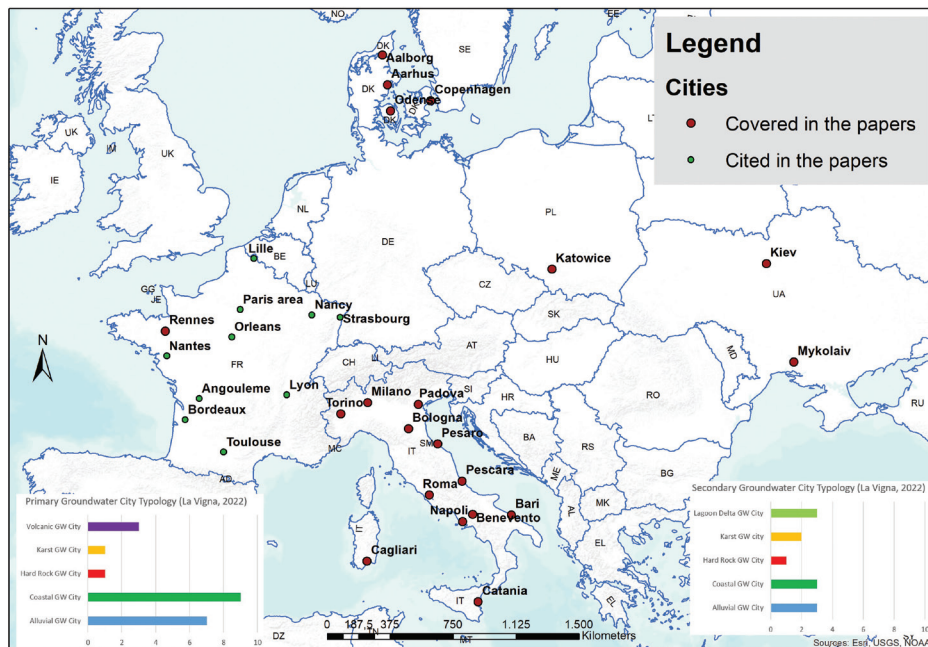


Fig. 1 - Cities covered and cited in the papers of the Special Issue. The two graphs show the primary and secondary occurrence of the different “groundwater city” typologies according to La Vigna (2022).

The first paper, by Quevauviller et al. (this volume), delves into the critical topics of urban water security and safety. Two review papers present several cities within the same country, for Denmark (Jørgensen et al., this volume) and Italy (La Vigna et al., this volume), respectively. In addition, a review of water infiltration potential in urban subsurface areas in French cities, with a particular focus on Rennes, is presented by Lucassou et al. (this volume). Several other papers focus on specific urban issues or projects, offering valuable insights into diverse European cities. For example, there are four papers from Italy: one on urban water management in Milan (Sartirana et al., this volume), another on the impact of human activities on groundwater in Pesaro (Farina & De Angelis, this volume), one addressing a review on water supply challenges in Benevento (Esposito et al., this volume), and one paper about the groundwater monitoring network of Rome (Roma et al., this volume).

Other contribution spotlight groundwater supply challenges in Katowice (Razowska-Jaworek, this volume), while two papers focus on Ukrainian cities: the first explores the impact of groundwater factors on a heritage site in Kyiv (Cherevko et al., this volume), while the second examines the potential for groundwater to supply the city of Mykolaiv during the Russian war on Ukraine (Shestopalov et al., this volume) highlighting important water security issues covered in the Quevauviller et al. (this volume) paper.

This special issue not only brings attention to the complex interplay between urbanisation and groundwater in Europe but also highlights the need for an integrated approach to managing this often-overlooked resource (Bricker et al., 2024). Through a combination of scientific analysis, technical solutions, and socio-economic considerations, it offers a fresh perspective on the importance of sustainable groundwater management in European cities emphasizing the need for improved tools and regulations for subsurface inclusive spatial planning.

REFERENCES

- Bricker, S., Jelenek, J., van der Keur, P.; La Vigna, F.; O'Connor, S., Ryzynski, G.; Smith, M.; Schokker, J., Venk, G. (2024) Geoscience for Cities: Delivering Europe's Sustainable Urban Future. Sustainability 2024, 16, 2559. <https://doi.org/10.3390/su16062559>
- Cherevko, I., Kril, T., Bugai, D., & Shekhunova, S., (this volume). Impact of hydrogeological factors on geotechnical conditions of the Kyiv-Pechersk Lavra Monastery complex: lessons from three decades of monitoring. *Acque Sotterranee - Italian Journal of Groundwater*, 13(3), <https://doi.org/10.7343/as-2024-765>
- EEA (2024). WISE Freshwater – Freshwater Information System for Europe: Groundwater chemical status. <https://water.europa.eu/freshwater/europe-freshwater/water-framework-directive/groundwater-chemical-status> – accessed 23-09-2024.
- Esposito, E., Ginolfi, M., Leone, G., & Fiorillo, F., (this volume). Hydrogeological and historical aspects of the water supply of Benevento town since the Roman age. *Acque Sotterranee - Italian Journal of Groundwater*, 13(3), <https://doi.org/10.7343/as-2024-774>
- Farina, D., & De Angelis, S. (this volume). Groundwater in the city of Pesaro (Marche, Italy): anthropic impact and interference with the urban environment *Acque Sotterranee - Italian Journal of Groundwater*, 13(3), <https://doi.org/10.7343/as-2024-776>
- Henriksen, H. J., Schneider, R., Koch, J., Ondracek, M., Troldborg, L., Seidenfaden, I. K., Kragh, S. J., Bøgh, E., & Stisen, S. (2023) A New Digital Twin for Climate Change Adaptation, Water Management, and Disaster Risk Reduction (HIP Digital Twin). *Water (Switzerland)*, 15(1). <https://doi.org/10.3390/w15010025>.
- Hinsby, K., Négrel, P., de Oliveira, D., Barros, R., Venk, G., Ladenberger, A., Griffoen, J., Piessens, K., Calcagno, P., Götzl, G., Broers, H.P., Gourcy, L., van Heteren, S., Hollis, J., Poyiadjik, E., Cápová, D., & Tulstrup, J. (2024). Mapping and Understanding Earth: Open access to digital geoscience data and knowledge supports societal needs and UN Sustainable Development Goals. *Int J Appl Earth Obs Geoinf*, 130, 103835
- Ingemarsson, M.L., Weinberg, J., Rudebeck, T., Erlandsson, L.W., (2022). The Essential Drop to Reach Net-Zero: Unpacking Freshwater's Role in Climate Change Mitigation. Stockholm International Water Institute, Stockholm, Sweden.
- IPCC (2024). Special report on Climate Change and Cities. <https://www.ipcc.ch/report/special-report-on-climate-change-and-cities/> - accessed 23-09-2024
- Jørgensen, L.F., Troldborg, L., Ondracek, M., Seidenfaden, I.K., Kidmose, J., Vangsgaard, C., & Hinsby, K. (this volume). Groundwater resilience, security, and safety in the four largest cities in Denmark - *Acque Sotterranee - Italian Journal of Groundwater*, 13(3), <https://doi.org/10.7343/as-2024-803>
- La Vigna F. (2022) Review: Urban groundwater issues and resource management, and their roles in the resilience of cities. *Hydrogeology Journal*, 30, 1657–1683. <https://doi.org/10.1007/s10040-022-02517-1>
- La Vigna, F., Alberti, L., Da Pelo, S., Ducci, D., Fabbri, P., Gargini, A., Lasagna, M., Pappalardo, G., Polemio, M., & Rusi, S. (this volume). Exploring the aquifers shaping Italy's sub-urban landscape. *Acque Sotterranee - Italian Journal of Groundwater*, 13(3), <https://doi.org/10.7343/as-2024-806>
- Le Monde, 2023. The Map of Forever Pollution in Europe. https://www.lemonde.fr/en/les-decodeurs/article/2023/02/23/forever-pollution-explore-the-map-of-europe-s-pfas-contamination_6016905_8.html - accessed 26-09-2024
- Lucassou, F., Chrétien, P., Pinson, S., Barrière, J., & Le Guern, C. (this volume). Mapping the intrinsic potential of water infiltration in urban subsurface: feedback from France. *Acque Sotterranee - Italian Journal of Groundwater*, 13(3), <https://doi.org/10.7343/as-2024-776>
- Quevauviller, P., Hinsby, K., Seidenfaden, I.K., Pulido-Velázquez, D., Sapiano, M., Coelho, R., Gartinessi, P., HohenBlum, P., Jirovsky, V., Marinheiro, F., Simas, L., Teixeira, R., Ugarelli, R., Cardarilli, M., Paraskevopoulos, S., Vrachimis, S., Gertjan, M., Eliades, D. & La Vigna F. (this volume). Urban water security and safety. *Acque Sotterranee - Italian Journal of Groundwater*, 13(3),
- Richardson, K., Steffen, W., Lucht, W., Bendtsen, J., Cornell, S.E., Donges, J.F., Drüke, M., Fetzer, I., Bala, G., von Bloh, W., Feulner, G., Fiedler, S., Gerten, D., Gleeson, T., Hofmann, M., Huiskamp, W., Kummer, M., Mohan, C., Nogués-Bravo, D., Rockström, J., 2023. Earth beyond six of nine planetary boundaries. *Sci. Adv.* 9, eadh2458
- Roma, M., Bonfà, I., Congi, M.P., Gafa, R.M., Martarelli, I., Monti, G.M., Papiccio, C., Silvi, A., Vitale, V., & La Vigna, F. (this volume). Guardians of the Aquifers: Enhancing Rome's Groundwater Monitoring Network. *Acque Sotterranee - Italian Journal of Groundwater*, 13(3), <https://doi.org/10.7343/as-2024-812>
- Sartirana, D., Zanotti, C., Rotiroli, M., Caschetto, M., Redaelli A., Bruno S., Dumagalli L., De Amicis M., & Bonomi T. (this volume). Urban Water Management in Milan Metropolitan Area. *Acque Sotterranee - Italian Journal of Groundwater*, 13(3), <https://doi.org/10.7343/as-2024-763>
- Sentek, Z., Prtorić, J., Pilz, S., Renson, I., Eckert, M., Tudela, A., Delgado, A., Aubert, R., Boutsis, M. & Sanchez, L. (2024). Under the surface – the hidden crisis in Europe's groundwater. <https://europeanwaters.eu/> - accessed 23-09-2024.
- Shestopalov, V., Rudenko, Yu., Koliabina, I., Stetsenko B., & Yaroshenko K. (this volume) Groundwater for urban water supply in Ukraine: a case study of Mykolaiv (Military challenges and lessons for the future) - *Acque Sotterranee - Italian Journal of Groundwater*, 13(3), <https://doi.org/10.7343/as-2024-772>
- United Nations, 2022. The United Nations World Water Development Report 2022: Groundwater: Making the invisible visible. UNESCO, Paris. <https://unesdoc.unesco.org/ark:/48223/pf0000380721>.
- Volchko, Y., Norrman, J., Ericsson, L.O., Nilsson, K.L., Markstedt, A., Öberg, M., Mossmark, F., Bobylev, N., Tengborg, P., 2020. Subsurface planning: Towards a common understanding of the subsurface as a multifunctional resource. *Land Use Policy* 90, 104316. <https://doi.org/10.1016/j.landusepol.2019.104316>.