

Recent Advances in Modern Hydrogeology: Promoting Harmony between Nature and Humanity

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Hydrogeology is a crucial branch of Earth science dedicated to deciphering the complex interactions between groundwater and the lithosphere, hydrosphere, atmosphere, and biosphere [1]. This discipline has taken on paramount importance as human demand for water resources has escalated in response to burgeoning population growth and rapid industrialization [2]. The distribution and utilization of these resources are profoundly shaped by both natural conditions and human activities, underscoring the need for comprehensive hydrogeological research [3].

The evolution of hydrogeology has been intrinsically tied to human needs. Initially, it emerged to meet demands for drinking water and irrigation in agriculture. As society progressed, hydrogeology evolved to support industrial development, where groundwater became a critical element for production. Today, the scope of hydrogeology has broadened to encompass diverse sub-disciplines such as eco-hydrogeology, which explores the interplay between ecology and hydrogeology; medical hydrogeology, which investigates the health impacts of hydrogeological processes; and hazard hydrogeology, which focuses on applying hydrogeological techniques to prevent geological hazards [4–6].

Hydrogeology serves as a vital bridge between nature and human society. It not only illuminates the formation, evolution, and distribution patterns of groundwater systems, but also provides a scientific foundation for the judicious development, utilization, and management of groundwater resources [7]. By probing the interactions between groundwater, surface water, and atmospheric precipitation, hydrogeology enables the prediction and assessment of changing groundwater resource trends [8,9]. This knowledge equips us to tackle pressing environmental issues, such as water scarcity and pollution. Moreover, the findings obtained from hydrogeological research are indispensable for informed decision making across a multitude of domains, including urban planning, engineering construction, and agricultural production [10]. In this way, it not only concerns the safeguarding and sustainable development of the natural environment, but also directly impacts the economic prosperity and security of human society.

1. Important Research Topics in Modern Hydrogeology

Modern hydrogeology is a multifaceted discipline that explores the relationships between groundwater and various natural elements, such as geology, soil, ecosystems, and climate [11,12]. It also investigates the interplay between groundwater and human activities, including aspects such as human health, groundwater pollution remediation, and groundwater resource management [13,14]. This article provides a comprehensive overview of eight significant research directions within modern hydrogeology, serving as a valuable resource for readers.



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- (1) **Groundwater Formation and Evolution**
Research into the formation and evolution of groundwater forms the cornerstone of hydrogeological studies. It encompasses the fundamental processes of groundwater creation, distribution, flow, and cycling [15]. This field's research focuses include the hydrogeological conditions affecting groundwater, its dynamic changes, the physical and chemical processes driving groundwater flow, and the interactions between groundwater and other elements like surface water, atmosphere, biota, and rocks.
- (2) **Groundwater Pollution and Remediation**
Groundwater pollution is a pressing global issue that directly influences human health and ecosystem stability [16,17]. Research in this area includes identifying pollution sources, understanding the migration and transformation processes of pollutants in groundwater, assessing the risks associated with groundwater pollution, and developing effective remediation techniques and strategies.
- (3) **Groundwater and Human Health**
As a primary source of drinking water for humans, groundwater directly impacts human health based on its quality [18,19]. Research in this domain includes studying the effects of harmful substances in groundwater (such as heavy metals and organic pollutants) on human health, assessing the health risks associated with groundwater pollution, and devising strategies to prevent and control waterborne diseases through groundwater quality improvement.
- (4) **Groundwater and Soil Environment**
The interplay between groundwater and the soil environment represents an interdisciplinary field bridging soil science and hydrogeology. Groundwater fluctuations typically affect the physical and chemical properties of soil, influencing processes like soil salinization, desertification, and soil erosion [20,21]. This field focuses on the mechanisms of groundwater changes impacting the soil environment, the coupling process of groundwater and the soil environment, and improving soil conditions through effective groundwater management.
- (5) **Groundwater and Environmental Geological Disasters**
The relationship between groundwater and environmental geological disasters is a significant area of geological environmental research. Changes in groundwater can impact the stability of the geological environment, triggering disasters such as loess landslides, ground subsidence, and ground collapse [6,22]. This field researches the mechanisms of groundwater changes impacting geological environmental stability, the coupling process of groundwater and geological disasters, and strategies to prevent and mitigate geological disasters through groundwater management.
- (6) **Management of Groundwater Resources and Groundwater Environments**
The scientific and effective utilization and protection of groundwater resources is the main focus in groundwater environmental management [23,24]. Research in this field includes assessing and predicting groundwater resources, understanding the effects of groundwater extraction and utilization, determining groundwater protection zones, and developing policies and regulations concerning groundwater resources.
- (7) **Groundwater and Ecosystems**
The interaction between groundwater and ecosystems is a crucial research direction within modern hydrogeology. It involves the interplay between groundwater and various ecosystems, such as wetlands, forests, and grasslands [25,26]. This field focuses on studying the impact of groundwater on ecosystems, determining the water demand of ecosystems for groundwater, and understanding the coupling process of groundwater and ecosystems.
- (8) **Groundwater and Climate Change**
The relationship between groundwater and climate change is an emerging topic in modern hydrogeology. It focuses on understanding the impact of climate change on groundwater and the feedback mechanisms of groundwater to climate change [27,28]. One of the most significant challenges that is currently faced by hydrogeology is ad-

addressing the impact of global climate change on water resources. With global warming, extreme climate events such as heavy rain and drought have become more frequent, posing severe threats to the safety and sustainable use of water resources [29,30]. These climate changes not only disrupt the patterns of the hydrological cycle, leading to uneven spatial and temporal distributions of water resources, but they also exacerbate issues like water shortage, water pollution, and water disasters.

Hydrogeology must delve deeper into the mechanisms of climate change's impact on groundwater systems, predict and assess the changing trends of groundwater resources, and propose adaptive management strategies. Simultaneously, it must consider the impact of human activities on the hydrogeological environment and reinforce water resource protection and environmental remediation efforts. In this process, hydrogeology needs to foster interdisciplinary collaboration to effectively address these intricate and pressing challenges.

2. Actions to Meet Challenges

With the growing global population and the acceleration of urbanization, the demand for water resources is continually increasing. Determining how to realize the sustainable use of groundwater resources while meeting the development needs of human society is a significant challenge in modern hydrogeology. Therefore, modern hydrogeology needs to continuously promote innovative research methods and technical means, improve research levels and practical abilities, and provide robust scientific support to face these challenges. Multiple perspectives are needed to achieve the sustainable use of groundwater resources.

Firstly, in-depth research into groundwater systems is required to understand the distribution, reserves, quality, and dynamic changes of groundwater resources. This understanding will form the basis for developing rational groundwater resource utilization strategies. Attention must also be paid to the impacts of climate change and human activities on groundwater systems to promptly respond to the potential issues caused by these factors [31].

Secondly, modern hydrogeology should promote technological innovation and application, such as developing efficient groundwater extraction and utilization technologies, optimizing groundwater resource allocation, and reducing waste. Simultaneously, by promoting advanced groundwater monitoring and prediction technologies, real-time changes in groundwater resources can be grasped, providing a scientific basis for decision making [32].

Furthermore, interdisciplinary cooperation and exchange is the key to realizing the sustainable use of groundwater resources [33]. Hydrogeological researchers need to work closely with scientists in other disciplines, such as environmental science, ecology, and engineering, to solve difficult problems in groundwater resource utilization. By sharing research results and experiences, the sustainable use of groundwater resources can be promoted more effectively.

In addition, education and training are indispensable [34]. By cultivating more talents with knowledge of hydrogeology, society's understanding and emphasis on the sustainable use of water resources can be improved, promoting the formulation and implementation of relevant policies and regulations.

Finally, policy guidance and public participation are crucial guarantees for the sustainable use of water resources. Governments should introduce relevant policies to encourage and support the rational use and protection of water resources [35,36], and public propaganda and education should be strengthened to improve the public's understanding of and participation in the sustainable use of water resources.

In summary, to achieve the sustainable use of groundwater resources, efforts in multiple areas are needed, including conducting in-depth research into groundwater systems, promoting technological innovation and application, strengthening interdisciplinary cooperation and exchange, enhancing education and training, and promoting policy guidance and public participation.

3. Papers in this Issue

To report the latest achievements in modern hydrogeology, this Special Issue published nine review papers after rigorous peer review. These review papers summarize and introduce the recent developments in various groundwater-related research directions. Their main themes include groundwater-related geohazard, groundwater resource management, groundwater pollution and human health, and groundwater circulation. These review papers are listed in Table 1, and their main contributions are summarized.

Table 1. Review article information published in this Special Issue.

No.	Authors	Article Titles	Years, Volumes, Issues, and Article Numbers	Contributions
1	Dong D. and Zhang J.	Discrimination methods of mine inrush water source	2023, 15(18), 3237	Contribution 1
2	Bhavya R. and Elango L.	Ant-inspired metaheuristic algorithms for combinatorial optimization problems in water resources management	2023, 15(9), 1712	Contribution 2
3	Ravindiran G. et al.	A review of the status, effects, prevention, and remediation of groundwater contamination for sustainable environment	2023, 15(20), 3662	Contribution 3
4	Marghade D. et al.	Arsenic contamination in Indian groundwater: from origin to mitigation approaches for a sustainable future	2023, 15(23), 4125	Contribution 4
5	Guo J. et al.	Worldwide distribution, health risk, treatment technology, and development tendency of geogenic high-arsenic groundwater	2024, 16(3), 478	Contribution 5
6	Prapanchan V.N. et al.	A global perspective on microplastic occurrence in sediments and water with a special focus on sources, analytical techniques, health risks, and remediation technologies	2023, 15(11), 1987	Contribution 6
7	Babuji P. et al.	Human health risks due to exposure to water pollution: a review	2023, 15(14), 2532	Contribution 7
8	Sabarathinam C. et al.	A review of the publications on carbon isotopes in groundwater and rainwater	2023, 15(19), 3392	Contribution 8
9	Gantayat R.R. and Elumalai V.	Salinity-induced changes in heavy metal behavior and mobility in semi-arid coastal aquifers: a comprehensive review	2024, 16(7), 1052	Contribution 9

The review article by Dong and Zhang (contribution 1) provides a comprehensive overview of various standard methods used to identify the source of mine water inrush, including hydrochemistry examination, water level and temperature analysis, geostatistical approaches, and machine learning methods, among others. It presents a detailed analysis of these methods, their strengths and weaknesses, and their applicability to different mining operations, and it highlights the increasing use of artificial intelligence in source discrimination models. The article also suggests future research directions, emphasizing the needs for more accurate models and to explore emerging technologies like IoT and cloud computing, with the ultimate goal of enhancing mining safety and efficiency.

The study by Bhavya and Elango (contribution 2) critically reviews the applications of ant colony optimization (ACO), a metaheuristic algorithm inspired by ant behavior, in the field of hydrology and hydrogeology. The review also discusses the implementation of hybrid and modified ACO techniques, which have been shown to be more efficient than traditional ACO algorithms. While acknowledging the potential of ACO, the study also identifies current challenges, including unresolved mathematical analysis, the incorporation of uncertainty, and issues with dimensionality, convergence, and stability. Despite these

challenges, it argues for further research on ACO due to its potential to formulate near-optimal solutions and improve cost efficiency.

Ravindiran et al. (contribution 3) examines the global depletion and contamination of groundwater resources, focusing on the situation in India and China, where groundwater utilization for agriculture is high. It discusses how various factors like aquifer characteristics, topography, subsurface activities, climate, and geochemical processes influence groundwater availability, and how anthropogenic activities, including agriculture and industry, contribute to pollution and depletion. The study highlights the serious health impacts of unsafe water; discusses the need for more knowledge about contaminant concentrations, behaviors, cycling, and degradation pathways; and suggests mitigation methods, including limiting and optimizing the use of organic and inorganic fertilizers, disposing pesticide waste, and disposing empty containers.

The review by Marghade et al. (contribution 4) provides a comprehensive examination of the issue of arsenic (As) contamination in India's groundwater. It discusses the complex geochemical processes of arsenic mobilization, transport, and distribution in groundwater and reviews the health risks associated with drinking arsenic-contaminated water. It also explores mathematical models, geographical analysis, and data-driven modeling specific to Indian groundwater and assesses various arsenic removal methodologies and factors influencing arsenic mobility.

The work by Guo et al. (contribution 5) presents a thorough literature review and analysis of the research progress on groundwater with high concentrations of geogenic As. It discusses the distribution, health risks, in situ remediation, regulatory technologies, and development trends related to high-As groundwater, primarily found in the inland basins and river deltas of countries in South Asia, East Asia, and South America. The review highlights the use of hydrogeological data and field measurements for modeling high-As risk areas, which aids in assessing and measuring potential areas of high-As groundwater. In situ rapid detection and remediation techniques are emphasized for promptly and effectively providing safe drinking water to affected areas. Several household- or community-scale As removal technologies are introduced.

The review by Prapanchan et al. (contribution 6) addresses the environmental threat posed by microplastics due to increased global plastic production. It explores the distribution, toxicity, and removal of microplastics, focusing on their presence in sediment, water, and salt and their impact on human health. It also discusses various removal techniques, categorizing them into engineered, biopolymer, and bioengineered approaches.

The review by Babuji et al. (contribution 7) compiles data from various studies to understand the types of contamination and the effects of water contamination on public health. The study involves understanding the biological, chemical, and physical processes controlling the movement of contaminants underground. It highlights the health risks associated with anthropogenic and geogenic pollution, microplastics, pharmaceuticals, and heavy metals. Remedial measures and mitigation strategies for water conservation, replenishment, and sustainability are also put forward.

The review by Sabarathinam et al. (contribution 8) focuses on the use of carbon isotopes in studying the hydrological cycle. It analyzes previous research on groundwater and precipitation isotopes, highlighting a lack of studies on carbon storage and $\delta^{13}\text{C}$ in arid regions. The review calls for more comprehensive investigations and acknowledges the role of the International Atomic Energy Agency in facilitating such research. However, it notes that the need for advanced equipment in such studies limits their feasibility to nations with robust scientific infrastructures.

Lastly, the review by Gantayat and Elumalai (contribution 9) examines the behaviors of trace metals in semi-arid coastal aquifers from six different countries. It finds that environmental factors, including evaporation, seawater intrusion, and pH levels, significantly influence the toxicity and bioavailability of various trace metals. The study highlights the importance of understanding these factors in managing and mitigating the risks associated with trace metal contamination in these vulnerable aquifers.

4. Final Remarks

The review papers presented in this Special Issue highlight the critical challenges and advancements in modern hydrogeology. These studies show that the challenges facing our groundwater resources are multifaceted and require a comprehensive understanding of various factors, from the geological and chemical compositions of aquifers to the impacts of climate change and human activities.

Moreover, the presented research demonstrates the power of international collaboration in addressing these global challenges. The diverse geographical representation of the studied aquifers, spanning six different countries, underscores the universality of these issues and the necessity for a globally coordinated response.

As we continue to increase our understanding of hydrogeological systems and the challenges they face, the insights gained from this Special Issue will serve as valuable resources for researchers, policymakers, and practitioners alike. They remind us of the urgency of our task and the need for continued research and action in the field of hydrogeology.

In the face of these challenges, the field of hydrogeology is ripe with opportunities for innovation and discovery. We hope to inspire further research and collaboration to continue safeguarding our precious groundwater resources for future generations.

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List of Contributions

1. Dong, D.; Zhang, J. Discrimination Methods of Mine Inrush Water Source. *Water* **2023**, *15*, 3237. <https://doi.org/10.3390/w15183237>.
2. Bhavya, R.; Elango, L. Ant-Inspired Metaheuristic Algorithms for Combinatorial Optimization Problems in Water Resources Management. *Water* **2023**, *15*, 1712. <https://doi.org/10.3390/w15091712>.
3. Ravindiran, G.; Rajamanickam, S.; Sivarethinamohan, S.; Karupaiya Sathaiah, B.; Ravindran, G.; Muniasamy, S.K.; Hayder, G. A Review of the Status, Effects, Prevention, and Remediation of Groundwater Contamination for Sustainable Environment. *Water* **2023**, *15*, 3662. <https://doi.org/10.3390/w15203662>.
4. Marghade, D.; Mehta, G.; Shelare, S.; Jadhav, G.; Nikam, K.C. Arsenic Contamination in Indian Groundwater: From Origin to Mitigation Approaches for a Sustainable Future. *Water* **2023**, *15*, 4125. <https://doi.org/10.3390/w15234125>.

5. Guo, J.; Cao, W.; Lang, G.; Sun, Q.; Nan, T.; Li, X.; Ren, Y.; Li, Z. Worldwide Distribution, Health Risk, Treatment Technology, and Development Tendency of Geogenic High-Arsenic Groundwater. *Water* **2024**, *16*, 478. <https://doi.org/10.3390/w16030478>.
6. Prapanchan, V.N.; Kumar, E.; Subramani, T.; Sathya, U.; Li, P. A Global Perspective on Microplastic Occurrence in Sediments and Water with a Special Focus on Sources, Analytical Techniques, Health Risks, and Remediation Technologies. *Water* **2023**, *15*, 1987. <https://doi.org/10.3390/w15111987>.
7. Babuji, P.; Thirumalaisamy, S.; Duraisamy, K.; Periyasamy, G. Human Health Risks due to Exposure to Water Pollution: A Review. *Water* **2023**, *15*, 2532. <https://doi.org/10.3390/w15142532>.
8. Sabarathinam, C.; Al-Rashidi, A.; Alsabti, B.; Samayamanthula, D.R.; Kumar, U.S. A Review of the Publications on Carbon Isotopes in Groundwater and Rainwater. *Water* **2023**, *15*, 3392. <https://doi.org/10.3390/w15193392>.
9. Gantayat, R.R.; Elumalai, V. Salinity-Induced Changes in Heavy Metal Behavior and Mobility in Semi-Arid Coastal Aquifers: A Comprehensive Review. *Water* **2024**, *16*, 1052. <https://doi.org/10.3390/w16071052>.

References

1. Hölting, B.; Coldewey, W.G. *Hydrogeology*; Springer: Heidelberg, Germany, 2019. [\[CrossRef\]](#)
2. Schirmer, M.; Leschik, S.; Musolff, A. Current research in urban hydrogeology—A review. *Adv. Water Resour.* **2013**, *51*, 280–291. [\[CrossRef\]](#)
3. Li, P.; Tian, R.; Xue, C.; Wu, J. Progress, opportunities and key fields for groundwater quality research under the impacts of human activities in China with a special focus on western China. *Environ. Sci. Pollut. Res.* **2017**, *24*, 13224–13234. [\[CrossRef\]](#) [\[PubMed\]](#)
4. Wan, L.; Cao, W.; Hu, F.; Liang, S.; Jin, X. Eco-hydrology and eco-hydrogeology. *Geol. Bull. China* **2005**, *24*, 700–703.
5. Li, P.; Wu, J. Medical geology and medical geochemistry: An editorial introduction. *Expo. Health* **2022**, *14*, 217–218. [\[CrossRef\]](#) [\[PubMed\]](#)
6. Li, P.; Wu, J.; Zhou, W.; LaMoreaux, J.W. *Hazard Hydrogeology*; Springer: Cham, Switzerland, 2023. [\[CrossRef\]](#)
7. Jia, X.; Hou, D.; Wang, L.; O'Connor, D.; Luo, J. The development of groundwater research in the past 40 years: A burgeoning trend in groundwater depletion and sustainable management. *J. Hydrol.* **2020**, *587*, 125006. [\[CrossRef\]](#)
8. Su, Z.; Wu, J.; He, X.; Elumalai, V. Temporal changes of groundwater quality within the groundwater depression cone and prediction of confined groundwater salinity using Grey Markov model in Yinchuan area of northwest China. *Expo. Health* **2020**, *12*, 447–468. [\[CrossRef\]](#)
9. Zhang, Q.; Li, P.; Ren, X.; Ning, J.; Li, J.; Liu, C.; Wang, Y.; Wang, G. A new real-time groundwater level forecasting strategy: Coupling hybrid data-driven models with remote sensing data. *J. Hydrol.* **2023**, *625*, 129962. [\[CrossRef\]](#)
10. Howard, K. *Urban Groundwater*; The Groundwater Project: Guelph, ON, Canada, 2023. [\[CrossRef\]](#)
11. Thaw, M.; GebreEgziabher, M.; Villafañe-Pagán, J.Y.; Jasechko, S. Modern groundwater reaches deeper depths in heavily pumped aquifer systems. *Nat. Commun.* **2022**, *13*, 5263. [\[CrossRef\]](#)
12. Xia, J.; Zhang, Y.; Mu, X.; Zuo, Q.; Zhou, Y.; Zhao, G. A review of the ecohydrology discipline: Progress, challenges, and future directions in China. *J. Geogr. Sci.* **2021**, *31*, 1085–1101. [\[CrossRef\]](#)
13. Syafiuddin, A.; Boopathy, R.; Hadibarata, T. Challenges and solutions for sustainable groundwater usage: Pollution control and integrated management. *Curr. Pollut. Rep.* **2020**, *6*, 310–327. [\[CrossRef\]](#)
14. La Vigna, F. Review: Urban groundwater issues and resource management, and their roles in the resilience of cities. *Hydrogeol. J.* **2022**, *30*, 1657–1683. [\[CrossRef\]](#)
15. Mádl-Szőnyi, J.; Batelaan, O.; Molson, J.; Verweij, H.; Jiang, X.-W.; Carrillo-Rivera, J.J.; Tóth, Á. Regional groundwater flow and the future of hydrogeology: Evolving concepts and communication. *Hydrogeol. J.* **2023**, *31*, 23–26. [\[CrossRef\]](#)
16. Karunanidhi, D.; Subramani, T.; Roy, P.D.; Li, H. Impact of groundwater contamination on human health. *Environ. Geochem. Health* **2021**, *43*, 643–647. [\[CrossRef\]](#) [\[PubMed\]](#)
17. Yin, X.; Feng, Q.; Li, Y.; Deo, R.C.; Liu, W.; Zhu, M.; Zheng, X.; Liu, R. An interplay of soil salinization and groundwater degradation threatening coexistence of oasis-desert ecosystems. *Sci. Total Environ.* **2022**, *806*, 150599. [\[CrossRef\]](#) [\[PubMed\]](#)
18. Ayejoto, D.A.; Egbueri, J.C. Human health risk assessment of nitrate and heavy metals in urban groundwater in Southeast Nigeria. *Ecol. Front.* **2023**, *44*, 60–72. [\[CrossRef\]](#)
19. Li, Y.; Bi, Y.; Mi, W.; Xie, S.; Ji, L. Land-use change caused by anthropogenic activities increase fluoride and arsenic pollution in groundwater and human health risk. *J. Hazard. Mat.* **2021**, *406*, 124337. [\[CrossRef\]](#) [\[PubMed\]](#)
20. Singh, A. Soil salinization management for sustainable development: A review. *J. Environ. Manag.* **2021**, *277*, 111383. [\[CrossRef\]](#) [\[PubMed\]](#)
21. Mirzavand, M.; Sadeghi, S.; Bagheri, R. Groundwater and soil salinization and geochemical evolution of Femenin-Ghahavand plain, Iran. *Environ. Sci. Pollut. Res.* **2020**, *27*, 43056–43066. [\[CrossRef\]](#) [\[PubMed\]](#)
22. Suganthi, S.; Elango, L. Estimation of groundwater abstraction induced land subsidence by SBAS technique. *J. Earth Syst. Sci.* **2020**, *129*, 46. [\[CrossRef\]](#)

23. Ahmad, A.Y.; Al-Ghouthi, M.A. Approaches to achieve sustainable use and management of groundwater resources in Qatar: A review. *Groundwater Sust. Dev.* **2020**, *11*, 100367. [[CrossRef](#)]
24. Gholami, V.; Sahour, H. A hybrid approach of supervised self-organizing maps and genetic algorithms for predictive mapping of arsenic pollution in groundwater resources. *Expo. Health* **2023**. (early access). [[CrossRef](#)]
25. Khan, Y.K.; Toqeer, M.; Shah, M.H. Characterization, source apportionment and health risk assessment of trace metals in groundwater of metropolitan area in Lahore, Pakistan. *Expo. Health* **2023**, *15*, 915–931. [[CrossRef](#)]
26. Thabrez, M.; Parimalarenganayaki, S. Hydrogeochemical characterization and non-carcinogenic health risk assessment of fluoride and nitrate-affected groundwater in northern parts of Tumkur district, Karnataka, India. *Hum. Ecol. Risk Assess.* **2024**. (early access). [[CrossRef](#)]
27. Yao, X.; Zhang, Q.; Chen, Y.; Sheng, Y.; Qi, H.; Yuan, T.; Ou, C. Spatiotemporal evolution of landscape ecological risk in Anhui section of the Huaihe River ecological and economic belt in China. *Hum. Ecol. Risk Assess.* **2024**. (early access). [[CrossRef](#)]
28. Amanambu, A.C.; Obarein, O.A.; Mossa, J.; Li, L.; Ayeni, S.S.; Balogun, O.; Oyebamiji, A.; Ochege, F.U. Groundwater system and climate change: Present status and future considerations. *J. Hydrol.* **2020**, *589*, 125163. [[CrossRef](#)]
29. Barbieri, M.; Barberio, M.D.; Banzato, F.; Billi, A.; Boschetti, T.; Franchini, S.; Gori, F.; Petitta, M. Climate change and its effect on groundwater quality. *Environ. Geochem. Health* **2023**, *45*, 1133–1144. [[CrossRef](#)] [[PubMed](#)]
30. Al Atawneh, D.; Cartwright, N.; Bertone, E. Climate change and its impact on the projected values of groundwater recharge: A review. *J. Hydrol.* **2021**, *601*, 126602. [[CrossRef](#)]
31. Wang, D.; Li, P.; He, X.; He, S. Exploring the response of shallow groundwater to precipitation in the northern piedmont of the Qinling Mountains, China. *Urban Clim.* **2023**, *47*, 101379. [[CrossRef](#)]
32. Miro, M.E.; Groves, D.; Tincher, B.; Syme, J.; Tanverakul, S.; Catt, D. Adaptive water management in the face of uncertainty: Integrating machine learning, groundwater modeling and robust decision making. *Clim. Risk Manag.* **2021**, *34*, 100383. [[CrossRef](#)]
33. Mazari, S.; Jalal, A. Environmental sociology: A social science approach to sustainability. *Odyssey Acad. Curiosit.* **2023**, *1*, 78–98.
34. Jimenez-Martinez, J. From the mental to the conceptual model: The challenge of teaching hydrogeology in the field. *Groundwater* **2023**, *61*, 768–771. [[CrossRef](#)] [[PubMed](#)]
35. Foster, S. Global Policy Overview of Groundwater in Urban Development—A Tale of 10 Cities! *Water* **2020**, *12*, 456. [[CrossRef](#)]
36. Molle, F.; Closas, A. Why is state-centered groundwater governance largely ineffective? A review. *Water* **2020**, *7*, e1395. [[CrossRef](#)]

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