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Editorial: Hydrological and hydrochemical processes in fragile ecosystems

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Editorial on the Research Topic
Hydrological and hydrochemical processes in fragile ecosystems

Background

An ecosystem is considered fragile when it exhibits a heightened susceptibility to disruption, degradation, or irreparable harm due to its limited capacity to withstand external stressors or adapt to changes. Fragile ecosystems, often delicate and unique, play a crucial role in maintaining biodiversity, ecosystem services, and global environmental equilibrium. These environments, encompassing wetlands, alpine regions, coastal areas, and more, are particularly vulnerable to the impact of hydrological and hydrochemical processes. As the world grapples with increasing environmental degradation and climate change, understanding and managing these processes in fragile ecosystems has become an urgent imperative, which is of paramount importance to mitigate their vulnerability and ensure long-term sustainability. This Research Topic aims to improve the knowledge on the processes of hydrology and hydrochemistry, their responses to changing environment, as well as the mechanisms of their ecological effects in fragile ecosystems. Eight papers are included in this Research Topic (Figure 1), encompassing a wide array of themes: (1) hydrologic dynamics and water cycle, (2) hydrochemical evolution, water quality, and risk assessment, and (3) environmentally friendly technology in ecosystems. These studies focus on fragile ecosystems, including drylands, Palm Grove ecosystems, urbanized ecosystems with risks of extreme weather events, and riverine systems with large water-diversion projects.

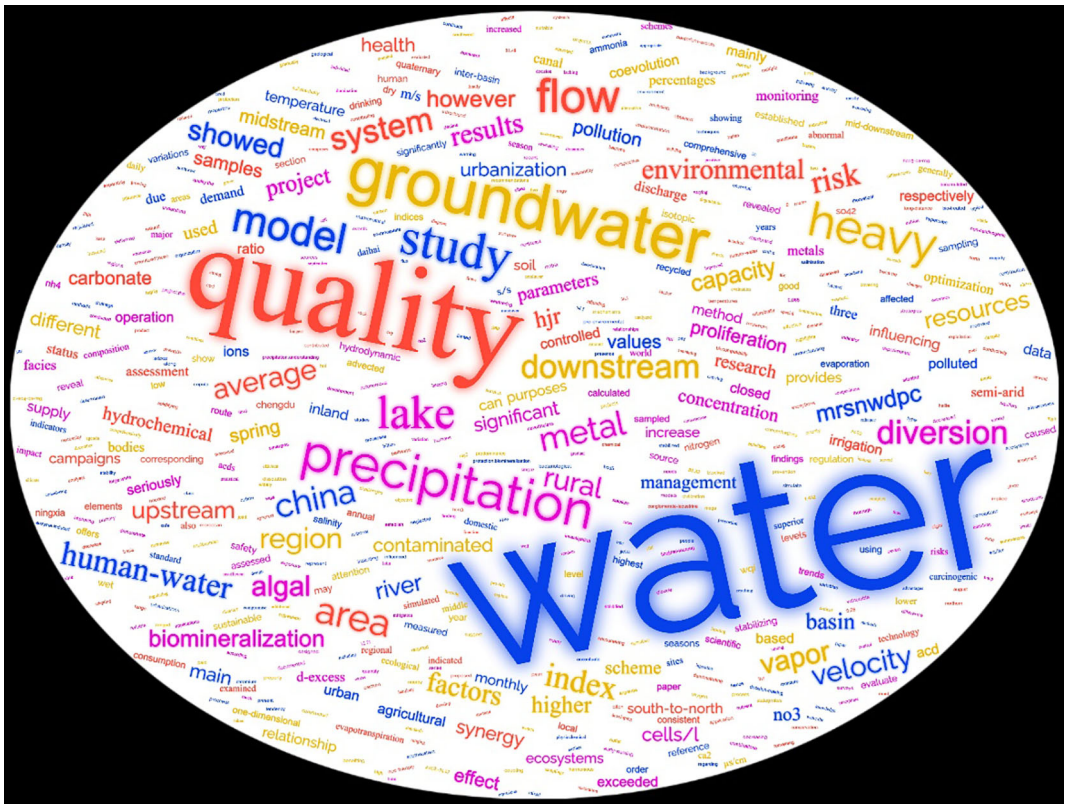

FIGURE 1
Word cloud of the abstracts of the eight articles within the Research Topic.

Hydrological dynamics and water cycle in fragile ecosystems

The intricate interplay between precipitation, evaporation, runoff, and groundwater recharge in fragile ecosystems significantly influences their overall health. Climate change-induced alterations pose severe challenges to water availability, impacting not only the ecosystems themselves but also the communities that rely on these resources. Two papers in this Research Topic discuss the water cycle and hydrological dynamics in China using the isotopic tracing techniques and coevolution model. Wei et al. investigate the dynamic interaction between human activities and water resources in the Ningxia Autonomous Region of China. Through a coevolution model and system dynamics analysis, the paper assesses different regulation schemes and reveals the worsening human–water relationship, highlighting the importance of a comprehensive optimization strategy to enhance the synergy between humans and water resources. Zhao et al. explore how urbanization impacts the isotopic composition of precipitation in Chengdu city and a nearby rural area. The study reveals that despite similar $\delta^{18}O$ values are observed in urban and rural precipitation, urbanization significantly decreases the proportion of vapor from local evapotranspiration contributing to precipitation, emphasizing the need to consider the effects of urbanization when using urban precipitation isotopic data in environmental studies or comparisons with rural areas.

Hydrochemical evolution, water quality, and risk assessment in fragile ecosystems

The hydrochemical composition of fragile ecosystems further shapes their sustainability. The interaction between surface water, groundwater, and soil characteristics directly affects nutrient cycling, water quality, and the persistence of endemic species. However, increased human activities, urbanization, and agricultural expansion can introduce pollutants into these systems, disrupting the delicate hydrochemical equilibrium and triggering ecological consequences. Five research papers report theoretical and practical findings in different contexts, broadening our understanding on the roles and patterns of hydrochemical processes in ecosystem degradation. Ait Said et al. investigate the groundwater quality in the Tinejdad-Touroug aquifer with vulnerable Palm Grove ecosystems in Southeast Morocco. The study reveals a complex hydrochemical evolution in the aquifer, characterized by changing major ion dominance and salinity levels, and underscores the importance of consistent monitoring and water resource management to ensure safe and sustainable usage, particularly in the face of rising salinity levels due to natural processes. Nong et al. address the challenge of abnormal algal proliferation in a major water diversion project of China. By analyzing monitoring data and applying complex modeling techniques, insights are obtained into the factors affecting algal

proliferation, and an effective early-warning management approach based on water temperature and flow velocity is proposed. Yang et al. assess the water environmental capacity of Helan County in Northwest China. By employing a mathematical model to simulate water quality and discharge, it is found that August experiences the most significant exceedance of water quality standards, particularly in BOD_5 and TN. Nong et al. discuss the impact of a large-scale water diversion project on the water quality and ecosystem of the Hanjiang River. The study reveals that while the water quality in the river remained generally "good" following the operation of the water diversion project, there were concerns related to increased human health risks, particularly from carcinogenic heavy metal chromium, highlighting the need for ongoing water quality safety management in the region. Ren et al. comprehensively assess the water quality and its influencing factors in the Daihai Lake Basin, a closed inland lake basin in a semi-arid region of China. The study analyzes data from various water sources and demonstrates the differences in hydrochemical characteristics and the suitability of water for different uses.

Environmentally friendly technology in fragile ecosystems

Environmentally friendly technologies could offer a sustainable path forward, as they minimize ecological disruptions and resource consumption. Such technologies enable responsible resource management, reduce pollution, and promote energy efficiency, which are critical for protecting the integrity of vulnerable ecosystems. In this Research Topic, Li et al. introduce the application of biomineralization technique on the solidification/stabilization of heavy metals. This method has been proven to be environmentally friendly, and has potential in addressing the environmental issues. The perspective also elucidates the constraints inherent in the process of biomineralization and presents potential avenues for future research in this field.

Towards a resilient future

The challenges presented by hydrological and hydrochemical processes in fragile ecosystems are not insurmountable. Through innovative research, adaptive management strategies, and global cooperation, we can pave the way towards a more resilient future. By acknowledging the delicate balance between human development and ecological preservation, we can foster a harmonious coexistence with these remarkable ecosystems.

In conclusion, the intricate dance of hydrological and hydrochemical processes within fragile ecosystems necessitates proactive management. As we stand at a critical juncture in the face of global environmental change, prioritizing the protection and sustainable management of these ecosystems is not just a choice; it's an ethical responsibility. Only through concerted efforts can we ensure the survival of these invaluable havens of biodiversity and ecological services for generations to come.

Author's note

All guest editors contributed equally to the ideas and reviews of this Research Topic.

Author contributions

CX: Writing – original draft, Writing – review & editing. GK: Writing – review & editing, Writing – original draft. NA: Writing – review & editing. JL: Writing – review & editing.

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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.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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