



OPEN ACCESS

EDITED BY

Vera I. Slaveykova,
Université de Genève, Switzerland

REVIEWED BY

Alessandro Piccolo,
University of Naples Federico II, Italy

*CORRESPONDENCE

Wei He,
✉ wei.he@cugb.edu.cn

SPECIALTY SECTION

This article was submitted to
Biogeochemical Dynamics,
a section of the journal
Frontiers in Environmental Science

RECEIVED 17 November 2022

ACCEPTED 28 November 2022

PUBLISHED 13 December 2022

CITATION

He W, Hur J, Chen M, Zhang P and
Semenov P (2022), Editorial:
Environmental biogeochemical
behaviors of humic substances and their
effects in the hydrosphere.
Front. Environ. Sci. 10:1101196.
doi: 10.3389/fenvs.2022.1101196

COPYRIGHT

© 2022 He, Hur, Chen, Zhang and
Semenov. This is an open-access article
distributed under the terms of the
[Creative Commons Attribution License
\(CC BY\)](https://creativecommons.org/licenses/by/4.0/). 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: Environmental biogeochemical behaviors of humic substances and their effects in the hydrosphere

Wei He^{1*}, Jin Hur², Meilian Chen³, Peng Zhang⁴ and
Petr Semenov⁵

¹Beijing Key Laboratory of Water Resources and Environmental Engineering, China University of Geosciences, Beijing, China, ²Department of Environment and Energy, Sejong University, Seoul, South Korea, ³Environmental Program, Guangdong Technion—Israel Institute of Technology, Shantou, China, ⁴State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Wuhan, Hubei, China, ⁵All-Russia Institute for Geology and Mineral Resources of the World Ocean (VNIIOkeangeologia), Saint-Petersburg, Russia

KEYWORDS

humic substances, biogeochemical interaction, bioavailability, surface water, groundwater, environmental behaviors, ecological effects

Editorial on the Research Topic

Environmental Biogeochemical Behaviors of Humic Substances and their Effects in the Hydrosphere

Knowledge of humic substances has been extended and updated since the first extraction of any such substance by Franz Karl Achard in 1786. However, what we know is still limited and there is a lack of universality in this domain (Steinberg, 2003). The development of state-of-the-art technology, including both analytical instruments and computing algorithms, has opened further doors in research on humic substances (Monda et al., 2021). As one of the major sets of carriers of organic carbon in the hydrosphere, humic substances link abiotic and biotic processes in aquatic ecosystems and play a critical role in global carbon cycling (Hedges and Oades, 1997). Humic substances are operationally defined and are believed to be supramolecular associations of relatively small molecules (Piccolo, 2002). Humic substances have complex chemical compositions (e.g., fulvic acids, humic acid, humin, and peptides) and functional groups (e.g., carboxyls, phenols, and hydroxyls). As a result, they present a diverse range of environmental biogeochemical behaviors and exert a range of effects, including in their interactions with other matter (e.g., nutrients, xenobiotics, pheromones, and electron acceptors/donors), facilitation of the release of toxics from underground minerals, acidification of water, attenuation of solar radiation, control of food webs, and even regulation of global matter cycling (Steinberg, 2003; Pérez and Sommaruga, 2006).

The aim of this Research Topic (RT) is to bring together a series of high-quality articles that outline recent advances in the field's understanding of the environmental

biogeochemical behaviors and effects of humic substances in the hydrosphere. The studies presented adopt approaches including field investigations, laboratory experiments, and model simulations that reveal the physio-chemical characteristics, interaction mechanisms, and environmental-biogeochemical roles and impact of humic substances. The RT can substantially improve the field's current understanding of the functions of humic substances, in ways that are relevant to a number of objectives, including the protection of dystrophic aquatic ecosystems, remediation of contaminated environments, and support of carbon-neutral technology.

This RT is intended to provide cutting-edge knowledge relating to humic substances in the hydrosphere, with the inclusion of articles on the following issues:

- The chemical composition, structure, and paleo- and contemporary environmental implications of humic substances in surface water, groundwater, and atmospheric water.
- Adsorption/desorption, aggregation/dissolution, photochemical reactions, binding behaviors, organic-mineral interaction, and diagenetic transformations of humic substances in various bodies of water.
- Acidification, the attenuation of solar radiation, climatic and hydrologic control, ecological regulation, and the geochemical determinants of humic substances in various bodies of water.
- The ecological roles and effects of humic substances and their internal and external influencing factors in aquatic ecosystems (e.g., humic lakes and other dystrophic ecosystems).
- The roles of humic substances in carbon budgets, carbon cycling, and carbon sequestration.

The five articles presented in this Research Topic consist of four original research articles and one systematic review. Owing to the presumably bio-refractory nature of humic substances, tracing the optical surrogates of humic substances alone is a method that can provide a wealth of information on the environmental fate of dissolved organic matter (DOM) and its dynamics in particular environments. Wang et al. showed that humic-like substances dominated fluorescent DOM pools in both the groundwater and river water in a coastal ecosystem. After estimating the organic matter fluxes, they highlight the important role of terrestrially derived allochthonous DOM sources by tracing optical surrogates (e.g., humic-like fluorescence) in coastal carbon and nutrient budgets. The allochthonous DOM fluxes of fresh groundwater discharge in western Guangdong were found to be of the same order of magnitude as that of river runoff.

With the development of ultrahigh-resolution mass spectrometry, it has become increasingly possible to establish

the molecular response of humic substances to hydrological conditions. Wang et al. investigated the mechanisms underlying the distribution variation in terrestrially derived and recalcitrant DOM dominated by humic-like substances in four tributaries of the Three Gorges Reservoir (TGR), the world's largest hydropower station, using optical techniques and ultrahigh-resolution mass spectrometry. The differences in the contents of humic-like substances between the front area (i.e., the area close to the dam) and other areas can be explained by the complex hydrological conditions induced by the dam. Additionally, the refractory nature of humic-like substances decreases the potential discharge of carbon dioxide; therefore, humic-like substances could play a crucial role in the sequestration of carbon in the hydrosphere. In another study conducted in the riparian zone of the TGR, Chen et al. quantified the effect of a flooding period on the decomposition and nutrient dynamics of leaves from artificially regenerated *Taxodium ascendens*. They found that the regulation of decomposition by hydrological process exerts control over the characteristics of organic matter in the riparian zone. Although this study did not focus entirely on the composition of organic matter, it still provides a valuable method of tackling these questions in relation to fresh organic matter or precursors of humic substances.

The adsorption, binding, and coprecipitating roles of humic substances in interaction with minerals can exert crucial environmental and ecological effects. Dai et al. demonstrated that the inhibition of coprecipitation with phosphate by algae-dominated water-soluble organic matter is stronger than in the case of macrophyte-dominated water-soluble organic matter, which is the precursor of humic substances, in a ternary coprecipitation system. Therefore, in the macrophyte-dominated zones of lakes or humic lakes, phosphorus might be deposited into the sediment through coprecipitation with iron and humic substances. Additionally, the fact that humic substances are reported to exhibit relatively higher coprecipitation with iron is reflected in the essential loss of carbon from reactive carbon pools. Yi et al. summarize the influencing factors in interactions between humic substances and goethite, and the subsequent environmental consequences. They point out that the resultant DOM-mineral complexes can affect the migration and transformation of heavy metals and emerging antibiotics. These complexes, as carriers of carbon and iron, also constitute critical components of the carbon and iron cycles, which are associated with climate change.

Although many researchers have explored the incidence, characteristics, and environmental fates of humic substances in the hydrosphere, many issues remain poorly understood, particularly regarding their roles in global and local carbon cycles and the secondary effects of their associations with other elements. To address these unresolved issues, we encourage further research using advanced techniques to decipher the complex structures of humic substances and to trace their alternative routes. We hope the papers presented in

this RT will promote dialogue, foster the exchange of ideas, and generate discussion with readers in the relevant field.

Author contributions

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

Funding

Study was provided by the National Natural Science Foundation of China (42177201), the Fundamental Research Funds for the Central Universities (265QZ2021004), and the Natural Science Foundation of Beijing Municipality (8202042).

References

- Hedges, J. I., and Oades, J. M. (1997). Comparative organic geochemistries of soils and marine sediments. *Org. Geochem.* 27 (7), 319–361. doi:10.1016/S0146-6380(97)00056-9
- Monda, H., McKenna, A. M., Fountain, R., and Lamar, R. T. (2021). Bioactivity of humic acids extracted from shale ore: Molecular characterization and structure-activity relationship with tomato plant yield under nutritional stress. *Front. Plant Sci.* 12, 660224. doi:10.3389/fpls.2021.660224
- Pérez, M. T., and Sommaruga, R. (2006). Differential effect of algal- and soil-derived dissolved organic matter on alpine lake bacterial community

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.

composition and activity. *Limnol. Oceanogr.* 51 (6), 2527–2537. doi:10.4319/lo.2006.51.6.2527

Piccolo, A. (2002). "The supramolecular structure of humic substances: A novel understanding of humus chemistry and implications in soil science," in *Advances in agronomy* (Academic Press), Cambridge, Massachusetts, United States, 57–134.

Steinberg, C. E. W. (2003). *Ecology of humic substances in freshwaters*. Berlin, Heidelberg: Springer.