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Editorial: Biogeochemical processes of micro/trace elements and their impacts on marine ecosystems

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Editorial on the Research Topic
Biogeochemical processes of micro/trace elements and their impacts on marine ecosystems

The micro/trace elements (M/TEs) concentrations in marine ecosystems (e.g., estuaries, salt marshes, mangrove forests, coral reefs, the open ocean, and the deep-sea ocean) are mostly very low. However, they play a key role in the functioning of these ecosystems, contributing to various biological and chemical processes. For instance, M/TEs such as Fe, Mn, Zn, and Cu, are essential components of nutrient cycles in marine ecosystems affecting the growth of phytoplankton and bacteria, and an essential nutrient for plant species in coastal ecosystems. Thus, M/TEs often limit primary production in certain regions of the ocean and coastal zones. Additionally, M/TEs elements such as Fe plays a role in redox reactions, influencing the oxidation and reduction processes that occur in estuarine soils affecting the potential of C sequestration and contaminants immobilization.

The maintenance of a balanced distribution of M/TEs is crucial for the preservation of biological communities and chemical processes within marine ecosystems. Any disruption in this balance can lead to abnormal ecosystem functioning. Consequently, the intensification of human activities has led to the substantial input of M/TEs into the marine environment which has given rise to a new frontier of investigation focusing on ecological roles and functions of M/TEs in the marine environment. M/TEs can function as vital nutrients or hazardous substances crucial for sustaining life, while certain M/TEs can also serve as indicators of changes in ecological conditions or levels of pollution. The cycling of M/TEs in the ocean is a highly intricate process, with their concentration and influence on marine ecosystems contingent upon the overall chemical matrix. This complexity is further evident in their interactions with various inorganic and organic substances, suspended particles,

colloids, and seafloor sediments. Consequently, the investigation of M/TEs in the ocean has consistently remained a prominent subject of interest in marine research.

Within this particular context, the 12 articles featured in this Research Topic center their attention on the biogeochemical mechanisms governing M/TEs within the ocean and their effects on the ecological environment. The research endeavors to encompass the identification of sources, distribution across multiple mediums, biogeochemical cycles, and interconnections with biodiversity, structure, and species function of M/TEs (and/or their isotopes) within the ocean. These articles are further categorized into two distinct classifications.

1 Source, multimedium distribution, and control mechanism of micro/trace elements and/or their isotopes in the ocean

Wang Z. et al. studied the distribution characteristics of dissolved Mn (dMn) in the East China Sea. The comprehensive biogeochemical cycle of dMn was found to be significantly influenced by various factors, including the input from the Yangtze River, the redox cycle, water mass mixing, and cross continental shelf transportation. Ren et al. investigated the spatial variations, sources, and correlations of dissolved Fe, Mn, Cu, Zn, Cd, and Pb in the surface water of the Yellow River Estuary in China. The study unveiled the specific molecular weight colloids that possess the ability to govern the distribution patterns of these metals in colloidal form. Luan et al. studied the fractionation behavior of Pb in seven seaward rivers in the Yellow River Delta, and discovered that the predominant transport form of dissolved Pb in freshwater was truly dissolved Pb. However, in brackish water within estuaries, colloidal matter gradually assumed the role of the primary transport carrier. The increase in salinity resulted in the immobilization of truly dissolved Pb, yet the presence of colloidal matter hindered this deposition process. Yang et al. found that the spatial patterns of dissolved Al (dAl) and dMn in the Northeast Indian Ocean were influenced to varying extents by the desorption and/or dissolution release of constituents from sedimentary rocks carried by riverine inputs, re-emergence of lithogenic particles, and the remineralization of organic particles. Wang X. et al. conducted a study on the early diagenesis of various redox sensitive metals in sediments obtained from the Bohai Sea, Yellow Sea, and Yangtze River Estuary. Their findings revealed a strong association between the cycling processes of Mo and Mn, whereas the recycling of U and V exhibited a closer relationship with Fe oxides. Cao et al. examined the distribution patterns of dissolved rare-earth elements (REEs) in the Northwest Pacific, and reported a significant positive correlation between REEs and apparent oxygen utilization in subsurface water. This study provides useful proxy information for tracing regional water masses and estimating cross-shelf REE fluxes.

The isotopic composition of oxidation-reduction sensitive elements holds significant value in the field of paleoceanography and serves as a tool for distinguishing pollution sources originating from natural processes and human activities. Wang W. et al. conducted an investigation on the dissolution of Cr and δ^{53}Cr throughout the water column. This study also incorporated data on dissolved and colloidal Fe concentrations, turbidity, chlorophyll a, dissolved oxygen, and large nutrient concentrations. The aim was to evaluate the regulatory mechanisms governing the behavior of Cr and its isotopes. Matsuoka et al. analyzed the source, concentrations, and isotopic ratios of dissolved Mo and W in waters and estuarine systems of Japan, the ratios of $\delta^{186/184}$W and $\delta^{98/95}$Mo were used to reveal the proportion from human activities.

2 Chemical forms of micro/trace elements and their coupling with biogeochemical cycles and ecological processes of other biogenic elements in the ocean

Fan et al. observed a non-conservative pattern of dissolved Mo (dMo) in relation to salinity in both the surface and bottom seawater of the Bohai Sea and Yellow Sea. The distribution of dMo was primarily influenced by biological utilization, particle adsorption (particularly MnO_x), and freshwater dilution. They emphasized that the significance of dMo in nitrification reduction outweighed its role in N fixation. Qi et al. conducted a study on the distribution and correlation of Fe, P, and total organic C (TOC) contents in three sediment cores from a coastal aquaculture area of Jiangsu Province, China, providing a valuable theoretical basis for further understanding and regulating the input of Fe minerals and P components in coastal sediments; thus controlling the burial rate and storage of TOC. The investigation conducted by Chen et al. focused on examining the dissolved inorganic nutrients and hydrochemical parameters of the Yongle Blue Hole, the deepest blue hole. The findings revealed notable seasonal variations in nutrients, N/P, and Si/P, as well as their correlation with oxidative conditions, indicating the influence of redox conditions on nutrient cycling in hypoxic seawater.

Seagrass meadows (SMs) are recognized as highly valuable ecosystems due to their provision of various ecosystem services and functions. Nóbrega et al. examined the intensity of Fe and sulfate reduction within SMs across diverse geographical environments, and investigated the resulting effects on archaea and bacterial communities. The findings revealed that the specific plant species present in these meadows influence soil geochemistry and microbial communities, facilitate the retention of fine particles, promote oxidation in the rhizosphere, and induce hypoxic conditions to regulate the formation of Fe and S.

The systematic study of the ecological functions of marine M/TEs remains incomplete, and there is still limited understanding of the coupling relationships between M/TEs and ecological communities. It is imperative to investigate the macro-level marine environmental behavior characteristics of M/TEs, as well

as the micro-level exploration of nutrient supply and ecological toxicology, encompassing processes within biological and non-biological systems. The accurate and highly sensitive quantitative determination of M/TEs in seawater serves as the fundamental basis for studying marine M/TE environmental biogeochemical processes. M/TEs are poised to assume a growing significance within the domains of marine ecological environment evolution, ecological function disclosure, and ecological risk assessment. Furthermore, the information unveiled by these M/TEs is expected to exhibit enhanced precision and accuracy. Consequently, the investigation of marine M/TEs' biogeochemistry in the marine environment is anticipated to emerge as a pivotal focal point within geoenvironmental studies.

This Research Topic contributed with valuable insights into the biogeochemical cycle of M/TEs and their influence on the marine ecological environment. Moreover, it endeavors to inspire the scientific community to undertake comprehensive and in-depth research, building upon the findings presented in this Research Topic. By collaborating, we aspire to safeguard the well-being and resilience of our oceans, marine ecosystems.

Author contributions

JS: Conceptualization, Data curation, Funding acquisition, Investigation, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. WZ: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. HQ: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Supervision, Validation, Writing – review & editing.

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Conflict of interest

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