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Editorial: The cycling of biogenic elements and their microbial transformations in marine ecosystems

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Editorial on the Research Topic
The cycling of biogenic elements and their microbial transformations in marine ecosystems

Introduction

The cycling of the major biogenic elements -carbon, nitrogen, and sulfur- has diversified life on Earth. Marine ecosystems, which cover 71% of the Earth's surface, contribute substantially to element cycling. Phytoplankton, zooplankton, and microorganisms are the main forces driving major biogenic element cycling in this ecosystem. In the Anthropocene, global warming, atmospheric sedimentation, eutrophication, ocean acidification, and hypoxia have caused many changes in the cycling. It is therefore of great interest to take a comprehensive look at these changes.

This Research Topic aimed to explore groundbreaking studies on the cycling of biogenic elements and their microbial transformations in marine ecosystems, offering insights into the complex interactions between microbial communities, carbon sequestration, and the biogeochemical processes that shape our oceans. In the Research Topic setup phase, we focused on 1) the impacts of global climate change on the spatiotemporal distribution patterns, migration and transformation processes of marine biogenic elements, 2) the role of microorganisms on the transformations of biogenic elements in marine ecosystems, 3) the responses of microbial communities to global changes in marine ecosystems, and 4) the interactions between biogenic elements and microorganisms facing global climate change that can be efficiently linked to the cycling of biogenic elements and their microbial transformations in marine ecosystems.

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The cycling of biogenic elements and their microbial transformations in marine ecosystems

In the marine ecosystem, almost all the energy source ultimately comes from phytoplankton, which is called photosynthesis. Chen et al. explored the post-transcriptional regulatory mechanism of selective RNA processing and stabilization (SRPS) in Synechococcus sp. PCC7002. In this study, the researchers found that the inactivation of SRPS enzymes significantly influences photosynthesis by affecting growth rate, pigment content, and the expression of key protein complex subunits involved in photosynthesis. The second study, by Wang R. et al., focused on the photochemical transformation of marine dissolved organic matter (DOM), particularly phytoplankton-derived DOM, highlighting the role of cyanate as a potential energy and nitrogen source for marine microbes. The third study, by Zeng et al., focused on the microbial transformation of biogenic elements in anaerobic areas. The study contributes to our understanding of the role of microorganisms in the transformation of biogenic elements in marine ecosystems and the implications for paleo-temperature or pH reconstructions. This Research Topic also included a comparison of microbial community respiration (MCR) methods between apparent oxygen utilization (AOU) and electron transport system (ETS) (Zhang et al.). This study indicated that oxygen consumption induced by nitrification causes the overestimation of MCR in the fall when evaluated from AOU. This research underscores the importance of considering the role of key microbial groups in the global carbon cycle. The above studies have focused on carbon transformation, highlighting the pivotal role of photochemistry and microorganisms in the cycling of biogenic elements.

For nitrogen cycling, this Research Topic contained the study by Huanca-Valenzuela et al., which focused on Diazotrophs, bacteria capable of biological nitrogen fixation. This study presented the metabolic versatility of marine microorganisms, using different nitrogen sources (such as urea and nitrate) between oxic and anoxic regions, by employing a multi-faceted approach. Another study, by Pei et al., explored the spatiotemporal distribution patterns of diazotrophic communities on *Gracilariopsis lemaneiformis*, which varied significantly among different cultivation periods and surroundings. This study underscores changes in nitrogenase activity and *nifH* gene abundance, which were influenced by environmental factors such as nutrient availability and temperature.

For sulfur cycling, Guo et al. showed that dimethyl sulfide (DMS) concentrations in the Yellow and East China Seas are positively correlated with Chl-a and sea surface temperature, but negatively correlated with sea surface salinity, highlighting the pivotal role of phytoplankton photosynthesis in sulfur cycling. We appreciate the innovative use of artificial intelligence to address the challenge of data scarcity in marine DMS observations.

Given the importance of microbes, our Research Topic also included their spatiotemporal distribution patterns. Weingarten et al. described the microbial diversity along an estuarine salinity gradient in the Mobile Bay estuary. They discovered that vegetation type, soil horizon, and salinity strongly influence microbial-soil relationships, with forested wetlands displaying distinct microbial biomes compared to other wetland types. Wang C. et al. uncovered the ecological stoichiometry of invertebrates in the Beibu Gulf, revealing significant interspecific differences in their elemental

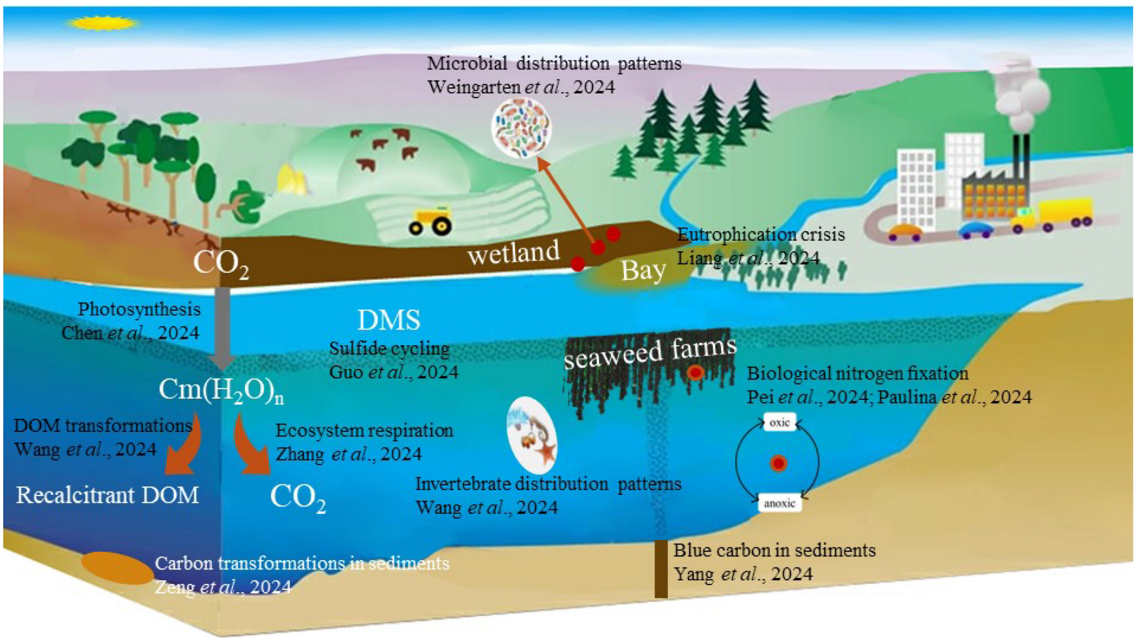

FIGURE 1
The schematic diagram of this Research Topic. DOM, dissolved organic matter; DMS, dimethyl sulfide.

composition and the influence of body size and food sources on these traits, highlighting the role of invertebrates in the biogeochemical cycling of nutrients and the potential impact of environmental changes on their growth and homeostasis.

The health of our oceans and their carbon sink function are the frontiers of marine science. In our Research Topic, Liang et al. provided a comprehensive analysis of nutrient dynamics and eutrophication in Zhanjiang Bay over two decades. Their study identified the main contributors to eutrophication and the impact of hydrodynamics and terrestrial inputs on nutrient concentrations, offering valuable insights for effective environmental management. They highlight the importance of considering local conditions, environmental factors, and ecological stoichiometry in managing and conserving marine ecosystems. The findings presented in this work not only advance our scientific knowledge but also provide a foundation for developing strategies to mitigate the impacts of eutrophication and promote the sustainable use of marine resources. Yang et al. investigated the composition of blue carbon in the sediments of a special type of marginal sea. The research reveals that sea-sourced carbon accounts for approximately 23% of the total carbon content in the sediments. The study also examined long-term changes in the blue carbon burial fluxes, which have been significantly affected by human aquaculture activities.

Perspectives

We thank all the researchers who have contributed and devoted their attention to this Research Topic. This Research Topic underscores the importance of cycling biogenic elements in the construction of the marine ecosystem, in addition to their biogeochemical transformations (Figure 1). However, further research is needed to address: 1) the multi-level responses of biogenic element cycling to global changes and anthropogenic disturbances, ranging from molecular to ecosystem scales; 2) long-term, continuous monitoring of biogenic element cycling in representative regions; 3) systemic biogeochemical processes in biogenic element cycling; 4) evaluation criteria for marine carbon sinks integrated with model forecasting; and 5) multi-omics and multidisciplinary approaches in the age of artificial intelligence (AI). All of the above are the innovative research being conducted in the field and serve as a foundation for future studies aimed at unraveling the mysteries of our oceans.

Author contributions

JD: Writing – original draft, Writing – review & editing. FW: Writing – review & editing. QC: 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.

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