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Editorial: Metal-organic interactions in seawater under changing anthropogenic and climate conditions

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Editorial on the Research Topic

Metal-organic interactions in seawater under changing anthropogenic and climate conditions

The speciation of metal ions in seawater and their interaction with other constituents present have been studied for 50 years (Duinker and Kramer, 1977; Branica, 1978), and comprehensively described in the literature (Bruland et al., 2014), with several facets of this important topic still remaining unanswered. Due to the increased anthropogenic pressure exerted on seas and oceans during the last decades, the topic has become challenging in many aspects not adequately investigated or pointed out before. Phytoplankton and metals have co-evolved throughout the history of the global ocean, with the former adapting to available trace nutrients, altering metal chemistry in surface waters, and metals modulating macro-nutrient fluxes by co-regulating phytoplankton growth (Sunda, 2012).

Organic ligands present in natural waters complex metal ions, which are thereby mobilized and transported towards different reservoirs within the aquatic system. Ligands largely consist of a pool of uncharacterized macromolecular organic material from a combination of different sources (e.g., phytoplankton exudates, bacterial community, utilization/transformation of organics, humic and fulvic substances, anthropogenic organic contaminants etc.). The associations of metals with organic matter can be characterized as complexation reactions, whereby cations associate with negatively charged functional groups of the organic molecule (or “surface groups” on the particulate matter). However, the direct sources of strong complexing ligands controlling metal speciation in seawater still remain insufficiently understood. Complexation by organic ligands generally decreases metal uptake, simultaneously enhancing their residence time in surface waters.

Interactions among metal ions and organics are influenced by different environmental processes such as climate change, elevated temperatures, different rainfall regimes and ocean acidification. The growing release of technology-critical elements (TCEs) (Ga, Ge, In, Nb, Ta, Te, Tl, platinum group elements (PGEs) and rare earth elements (REEs)) requires

comprehension of their mobility, reactivity and chemical transformations in the environment, which are critically dependent on their chemical forms.

In this Research Topic, [Sutorius et al.](#) studied REE behaviour and organic matter (OM) cycling during the phytoplankton spring bloom within a mesocosm. Their findings reveal that OM-cycling influences the concentration patterns of dREEs (dissolved rare earth elements) *via* ad- and desorption processes, as well as organic complexation with parts of the OM pool, suggesting that these processes may exert a significant impact on dREE concentrations in the natural marine environment under high OM conditions.

The manuscript by [Karavoltsov et al.](#) deals with the characterization of metal ligands in the marine surface microlayer (SML) of coastal areas, focusing on Cu, Zn and Cd, investigating interconnections with biota and providing the FTIR characterization of organic ligands present.

The seasonal speciation of dissolved copper in the Strait of Georgia, British Columbia, is the topic of the manuscript by [Vaughan et al.](#), highlighting the influence of freshwater and open ocean ligand sources, conservative mixing dynamics, and particulate Cu concentrations on dissolved copper (dCu) speciation within estuarine basins.

[Smith et al.](#) determined the potential sources of iron binding ligands in the coastal Antarctic environment. A closer look at data collection and a comparison with existing data reveals underlying intercalibration issues within the field of trace metal voltammetry and highlights priority areas of the Southern Ocean for future investigation, considering the influence of different iron binding groups on iron speciation in the marine environment.

The iron - gallic acid redox reaction in seawater and its influence on ocean acidification is investigated and discussed in the manuscript by [Pérez-Almeida et al.](#) The effect of gallic acid (GA; 3, 4, 5-trihydroxy benzoic acid) on Fe oxidation and reduction was studied. Gallic acid reduces Fe(III) to Fe(II) in seawater, making the presence of Fe(II) for longer time periods feasible and favouring its bioavailability.

[Gledhill et al.](#) examined the European Shelf Sea Waters regarding competitive interactions among microbial siderophores and humic-like substances. The heterogeneity characterizing the binding sites in the humic-like DOM fraction indicates that other binding sites present in organic matter could be effective competitors for siderophores, especially at low iron concentrations. Their findings highlight the importance of considering binding site heterogeneity when evaluating the influence of different iron binding groups on iron speciation in the marine environment.

[Völker and Ye](#) describe the feedback between ocean productivity and organic iron complexation related to changes in iron supply. The feedback strength increases with ligand lifetime. The negative feedback associated with siderophore-like

ligands potentially mitigates the positive feedback, especially at the surface and for global export production. However, additional research on the production and decay of siderophores is required for a better quantification. Ocean biogeochemical models assuming a constant ligand concentration and hence neglecting possible feedbacks may therefore underestimate the reaction of the global carbon cycle to the strong increase in dust deposition under future or glacial climate conditions.

The present Research Topic contributes to the effort of shedding light on and clarifying the important issues of chemical speciation of metal ions, their relation to biota and response to different climate and anthropogenic pressures. The studies included point to the diversity of metal ligands in the marine environment, which controls metal biogeochemistry and therefore their fate and transport in the environment.

Author contributions

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

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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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