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Editorial: Environmental behavior processes and mechanisms of organic pollutants in global coastal waters

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Editorial on the Research Topic

[Environmental behavior processes and mechanisms of organic pollutants in global coastal waters](#)

Coastal oceans represent invaluable natural capital and increasingly vulnerable frontiers for human health, livelihoods, and biodiversity. Across mangroves, estuaries, mariculture zones, and offshore wetlands, legacy persistent organic pollutants (POPs), emerging contaminants such as microplastics, and reactive organic chemicals co-occur with symptoms of eutrophication and harmful algal blooms (HABs). Superimposed on global warming and altered hydrology, these stressors reshape food webs, impair ecosystem services, and challenge traditional management paradigms. Meeting these challenges requires mechanistic insight into how contaminants partition across environmental media, transform through photochemical, microbial, and biogeochemical pathways, and feedback on ecological processes. This Research Topic assembles contributions that advance process-level understanding and demonstrate tools for risk characterization, monitoring, and remediation in coastal and special marine ecosystems.

A key pillar in managing coastal pollution is long-term, multimedia diagnosis of where contaminants reside, how they vary in space and time, and what drives those patterns.

Su et al. provide such an integrative perspective for POPs (HCHs, DDTs, PAHs) and heavy metals along the Bohai Sea coast. Through coordinated sampling of seawater, sediments, and biota over multiple years, complemented by geo-accumulation index (Igeo), potential ecological risk index (PERI), and provisional tolerable daily intake (PTDI) assessments, they reveal elevated burdens in estuarine and nearshore zones and identify arsenic, cadmium, and mercury as priority sediment pollutants. The authors also place human health in focus by evaluating seafood exposure, with arsenic emerging as the principal dietary concern across trophic groups. Importantly, their multivariate analyses trace pollutant distributions to anthropogenic controls underscoring source-to-sea linkages and the need for watershed–coast coordination (Su et al.).

Understanding pollutant behavior cannot be decoupled from the ecological state of receiving waters. HABs both respond to and mediate coastal biogeochemistry, altering nutrient cycling, oxygen dynamics, and food web structure. Shang et al. analyze seasonal succession of phytoplankton off Qinhuangdao, China using morphology, pigment analysis and high-throughput 18S rRNA sequencing. They document a reproducible shift from diatom dominance in early summer to dinoflagellates in late summer, linked to phosphate limitation and high N:P ratios, diminished riverine inputs during a dry year, and nitrogen regeneration associated with scallop farming; molecular evidence for cryptophyte blooms (*Teleaulax*) highlights how methodological complementarity refines ecological diagnosis (Shang et al.).

If eutrophication and HABs represent one end of the pollutant–ecosystem interaction, the micro-scale fate of algal organic matter represents another. Feng et al. probe mineralization of algae-derived organic nitrogen (AON) by *Skeletonema costatum* and show that modified clay used for bloom flocculation also suppresses AON mineralization and inorganic nitrogen regeneration. Using isotope dilution, fluorescence spectroscopy, and 16S rDNA profiling, they propose the mechanisms should be that physical encapsulation of AON within clay-organic flocs, chemical bonding including interactions with aluminum phases that strengthens organic matter protection, and shifts in bacterial communities toward taxa specializing in recalcitrant substrates, suggesting clay-based interventions can dampen post-bloom nutrient recycling and secondary eutrophication (Feng et al.).

Alongside process understanding, this Topic showcases enabling technologies for remediation. Alprol et al. present a sunlight-driven ZnO-doped activated carbon–ammonia composite that couples adsorption with photocatalysis to remove the azo dye Acid Red 14 from aqueous solutions. Through materials characterization, kinetic/isotherm modeling, and thermodynamic analysis, they demonstrate high removal efficiencies, endothermic and spontaneous behavior at elevated temperatures, and performance enhancement via H₂O₂-assisted radical generation, with partial reusability (Alprol et al.).

Reliable monitoring depends on robust sample preparation that isolates the signal of interest without compromising integrity.

Gao et al. introduce an alkaline K₂S₂O₈ pretreatment protocol that leverages thermally and alkalinity-activated sulfate and hydroxyl radicals to efficiently digest biogenic matrices in seawater samples while preserving common polymer chemistries. By benchmarking against Fenton's reagent and other chemistries using Raman/FTIR spectroscopy, SEM-EDS, and carbonyl indices, they show enhanced digestion efficiency with minimal surface oxidation or mass loss across polymers, enabling unambiguous spectroscopic identification of microplastics in biologically rich samples (Gao et al.).

Taken together, the contributions span scales and functions. Several cross-cutting themes emerge. First, hotspots and timing matter: estuarine mixing zones and aquaculture areas concentrate contaminants and biogeochemical processes, while seasonal hydrology and stoichiometry set the stage for community shifts and HAB risks (Su et al.; Shang et al.). Second, microbes are central agents in pollutant transformation; integrating microbial ecology with contaminant fate models will sharpen predictions (Feng et al.). Third, methods shape insight: combining orthogonal approaches reduces ambiguity and reveals hidden actors such as nanophytoplankton or recalcitrant organic fractions (Shang et al.; Feng et al.; Gao et al.). Finally, management benefits from portfolios that couple source control and engineered treatment with *in situ* ecosystem-based tools, guided by risk metrics that bridge ecological and human health endpoints (Su et al.; Feng et al.; Alprol et al.).

Looking ahead, we see priorities for the community. Process-resolving observatories that integrate multimedia contaminant measurements with ecosystem indicators in special coastal ecosystems would enable attribution of change to drivers and interventions. Harmonization of microplastic pretreatment and identification protocols is needed to build comparable baselines across regions (Gao et al.). Modeling frameworks that couple contaminant transport and transformation with nutrient dynamics and HAB ecology including the role of mariculture and climate variability will help evaluate cumulative risks and trade-offs (Shang et al.; Su et al.). On the remediation front, advancing sunlight-powered materials and nature-based approaches, with life-cycle assessments and field demonstrations, can accelerate deployment (Alprol et al.; Feng et al.). Finally, risk assessments that combine indices such as PERI, Igeo, and PTDI with ecotoxicological thresholds and ecosystem tipping points will better inform policy and One Health outcomes (Su et al.).

We thank the authors and reviewers for their contributions to this Topic. By illuminating mechanisms, refining tools, and connecting disciplines, these studies move us closer to a predictive and solutions-oriented science of organic pollutants in the coastal ocean.

Author contributions

KZ: Writing – original draft. OF-A: Writing – review & editing. YS: Writing – review & editing. H-HZ: Writing – review & editing. ZZ: Writing – review & editing.

Conflict of interest

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