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Trace Metal dynamics and risk assessment in Coastal Ocean Alkalinity Enhancemen

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Ocean Alkalinity Enhancement (OAE) adds alkaline minerals (e.g., olivine, brucite) or industrial byproducts (e.g., steel slag, red mud) to seawater, increasing alkalinity to enhance CO2 sequestration. Dissolution of these materials can release trace metals. Although some trace metals are essential for phytoplankton growth in micronutrient-limited regions, the large-scale dissolution required for effective OAE may elevate metal concentrations to potentially toxic levels. To assess the environmental feasibility and potential risks of OAE, we conducted a two-month mesocosm experiment using four alkaline materials (brucite, steel slag, olivine, and red mud) across different scales (55-L, 50,000-L, and 100,000-L). We conducted time-series measurements to track alkalinity, biological community composition, trace metal dynamics (Al, Cu, Fe, Mn, Ni, and Zn), and dissolved organic matter fingerprints over the course of the experiment. Our data reveal significant metal leaching from OAE materials such as steel slag, as well as a shift of biological communities with changes of carbonate chemistry driven by OAE deployment. These findings underscore the need for trace metal parameterized models, and further field-relevant mesocosm or in situ experiments, to evaluate risks prior to large-scale deployment.