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Atypical Seasonality of the Silicon Cycle in the Yellow River Estuary and Bohai Sea Revealed by Stable Silicon Isotopes

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Biogeochemical Si cycle in coastal areas is of vital importance due to its close link with the carbon cycle. However, the coastal Si cycle has been heavily perturbated by human activities. In this study, we studied the spatiotemporal distribution of biogenic Si (BSi) and dissolved Si (DSi) combined with stable Si isotopes of DSi ($\delta^{30}Si_{DSi}$) in the Yellow River estuary and Bohai Sea, one of the most populated coastal areas in the world. Over an annual cycle, BSi and DSi concentrations varied from 0 to 43.5 μmol L^{-1} and from 0.3 to 40 μmol L^{-1}, respectively. This was associated with large $\delta^{30}Si_{DSi}$ variations from +0.49 ± 0.22‰ (2sd) in spring to +2.92 ± 0.14‰ in winter, which opposed to observations that summer $\delta^{30}Si_{DSi}$ values were usually higher than those in winter. This atypical variation could be attributed to the water-sediment regulation on the Yellow River occurring every early summer, leading to a strong water mixing pattern and suppressing diatom production in summer. This mixing was further prolonged by extreme autumn rainfall on land. The pulse supply of nutrients subsequently enhanced primary productivity from autumn through winter. In spring, the resuspended seafloor sediments are likely an important DSi source with $\delta^{30}Si$ values of < -0.5‰. Our findings suggest that natural Si seasonality has been greatly masked by human activities and climate events in the Bohai Sea. Our study serves as a reference of the Si cycle research endeavors worldwide for revealing the overlaying effect of anthropogenic consequences and natural variability.