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Interactions of the sulfur, iron, and phosphorus cycles control phosphorus sequestration in estuarine sediments

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Interactions of the sulfur, iron (Fe), and phosphorus (P) cycles may be parts of global feedback loops that control P availability in the sea through linkages of primary productivity, atmospheric carbon dioxide, global temperature, sea level, and the sequestration or release of P from estuarine sediments. We investigated these interactions by measuring particulate P (PP) fractions and sequestration across estuarine salinity gradients. A sequential extraction technique was used to compare the forms and amounts of PP deposited in the top meter of sediment spanning salinities from 0-11 psu in four Chesapeake Bay sub-estuaries: the Potomac, Patuxent, Choptank, and Bush Rivers. Fe-bound P (i.e., citrate-bicarbonate-dithionite (CDB) extractable P) was the most dynamic fraction of PP, dominating oligohaline sediments (salinities <3 psu), but declining to near zero with depth in the most saline sediments except in the Patuxent. Particulate organic P was relatively constant with depth and salinity and became the dominant form of PP in the most saline sediments of all sub-estuaries, except the Patuxent. Fe-P was not replaced with diagenetic authigenic carbonate fluorapatite. Fe-P generally persisted in the oligohaline sediments to 1 m depth, where sediment ages ranged from 60-200 years, based on ^{210}Pb dating. Although the CDB extraction targets iron oxides, the predominant form of Fe in the sediments was ferrous, suggesting that the predominant form of PP in oligohaline sediments may be ferrous phosphate. As salinity increased above 3 psu, the pore water dissolved Fe:phosphate ratio decreased below 2, while the dissolved inorganic N:P ratio shifted from >16 to <16. This suggests that increasing salinities above 3 psu may supply enough sulfide to bind with the ferrous Fe in these sediments, thereby releasing dissolved phosphate from ferrous phosphate and changing the dissolved inorganic N:P ratio enough to promote a change in phytoplankton limitation from P to N. Future Increases in global temperature and sea level may lead to increases in estuarine salinity and decreases in dissolved oxygen that could stimulate phosphate release and primary productivity.