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Rapid nitrification of wastewater ammonium near coastal ocean outfalls, Southern California, USA

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ABSTRACT

In the southern California Bight (SCB), there has been a longstanding hypothesis that anthropogenic nutrient loading is insignificant compared to the nutrient loading from upwelling. However, recent studies have demonstrated that, in the nearshore environment, nitrogen (N) flux from wastewater effluent is equivalent to the N flux from upwelling. The composition of the N pool and N:P ratios of wastewater and upwelled water are very different and the environmental effects of wastewater discharges on coastal systems are not well characterized. Capitalizing on routine maintenance of the Orange County Sanitation District's ocean outfall, wherein a wastewater point source was "turned off" in one area and "turned on" in another for 23 days, we were able to document changes in coastal N cycling, specifically nitrification, related to wastewater effluent. A "hotspot" of ammonium (NH_4^+) and nitrite (NO_2^-) occurred over the ocean outfall under normal operations and nitrification rates were significantly higher offshore when the deeper outfall pipe was operating. These rates were sufficiently high to transform all effluent NH_4^+ to nitrate (NO_3^-). The dual isotopic composition of dissolved NO_3^- ($\delta^{15}N_{NO3}$ and $\delta\,^{18}O_{NO3}$) indicated that N-assimilation and denitrification were low relative to nitrification, consistent with the relatively low chlorophyll and high dissolved oxygen levels in the region during the study. The isotopic composition of suspended particulate organic matter (POM) recorded low $\delta\,^{15}N_{PN}$ and $\delta\,^{13}C_{PN}$ values around the outfall under normal operations suggesting the incorporation of "nitrified" NO_3^- and wastewater dissolved organic carbon into POM. Our results demonstrate the critical role of nitrification in nitrogen cycling in the nearshore environment of urban oceans.