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Nitrogen assimilation and dissimilation by bacteria and benthic microalgae in tidal mudflat sediment in a 15N labeling study

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In a short-term 15N-labeling experiment, we investigated the changes in relative utilization of reactive nitrogen in tidal flat sediment, focusing on the relative importance of assimilatory versus dissimilatory processes and the role of benthic microalgae therein. 15N-labeled ammonium and nitrate were added separately to homogenized tidal flat sediment, and 15N was subsequently traced into bulk sediment and inorganic nutrients in pore water. Integration of results in an N cycle model allowed us to quantify rates for the major assimilatory and dissimilatory processes in the sediment.

Overall, the results indicate that the equilibrium between assimilation and dissimilation in this tidal mudflat is mainly dependent on the nitrogen source: Nitrate is utilized almost exclusively dissimilatory via denitrification, whereas ammonium is rapidly assimilated, with about a quarter of this assimilation due to BMA activity. The major influence of benthic microalgae is on assimilation of ammonium, ceasing BMA activity turns the sediments from a net ammonium sink to a net source.

There is little evidence of dissimilative processes like nitrification in undisturbed sediments, but high initial nitrification rates suggest that in a dynamic environment like tidal flats, intense and fast nitrification/denitrification of ammonium is abundant. The driving mechanisms for assimilation or dissimilation accordingly appear to be ruled to a large extent by external physical forcing, with the entire system being capable of rapid shifts following environmental changes.

Our combined experimental and model approach reveals that selective removal of labeled compounds takes place for both ammonium and nitrate. Mechanisms remain unclear, but this finding clearly challenges the traditional labeling approach and underscores the need to consider selective uptake in future labeling studies. Ignoring such selective uptake mechanisms will lead to misinterpretation of process rates when these are estimated on the basis of label fluxes.