Nitrous oxide reduction by metabolically specialized bacteria in dynamic permeable sediments

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The sandy, permeable sediments that cover large expanses of the continental shelves are highly dynamic environments whose contribution to biogeochemical cycles have been largely neglected. However, O_2 consumption, N-loss and organic carbon turnover rates in sandy sediments appear to be amongst the highest in the marine environment. High rates result from advective porewater flow combined with the filtration capacity of sands, which enhance fluxes of electron acceptors and donors into the sediment substantially compared to muds. However, changes in bottom water current velocity and migration of sandy sediments cause variations in fluxes and redox conditions. This presents microorganisms with a challenge, as they must cope with rapid changes in the availability of O_2 and nitrate on time scales of minutes to hours. Such rapid changes are assumed to lead to incomplete denitrification and promote emissions of N_2O. We investigated how the dynamic conditions within the sandy sediments of the world's largest intertidal sand flat (Wadden Sea; North-West Europe) determine the functioning of the microbial community and the balance between N_2O and N_2 production. High denitrification rates lead to large N_2O emissions from the region, nevertheless, the N_2O production was not more than 1 to 4 % of total N_2 production. This efficient denitrification is driven by a metabolically specialized consortium of bacteria. In particular, N_2O reduction is carried out primarily by highly abundant Flavobacteria, which only encode and express N_2O reductase. A closely related Flavobacteria isolate from the region has one of the highest affinities for N_2O shown to date, indicating how this organism reduces almost all the N_2O produced within the sediment to N_2. Such organisms likely have a major impact on emissions of this potent greenhouse gas.