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The removal of bioavailable nitrogen in a hypereutrophic intertidal ecosystem

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Intertidal ecosystems are very dynamic ecosystems that act as a transition between freshwater and seawater areas, and are subjected to a loading of bioavailable nitrogen. An increase in available nitrogen loading in intertidal ecosystems causes eutrophication and macroalgae blooms. Denitrification and anaerobic ammonium oxidation (anammox) lead to the removal of available nitrogen, but few studies have examined this in intertidal sediments. In the present study, we investigated the sediment anammox and denitrification rates in September 2015 and November 2016 were measured using a 15N tracer technique at two sites, with and without macroalgae, in the hypereutrophic Yatsu tidal flat, eastern Japan. Yatsu tidal flat was isolated from Tokyo Bay by concrete dykes constructed in 1972 to reclaim the surrounding area for industrial and residential uses. In addition, to identify the environmental factors that control denitrification, the relationships between the long-term changes in denitrification activity, measured using the acetylene (C2H2) block method, and environmental factors were assessed statistically.

In sediments with and without macroalgae, the rate of N2 production via anammox was consistently low compared with that via denitrification, accounting for < 7% of the total N2 production. In a fed-batch incubation experiment, the anammox rate increased in the surface sediment after 3 months. However, the contribution of anammox to nitrogen removal did not exceed that of denitrification, suggesting that denitrification is the major pathway for conversion of inorganic nitrogen to N2, and that anammox plays a limited role in nitrogen removal in the Yatsu tidal flat. Denitrification activity measured from August 2012 to January 2017 using the acetylene block method was higher in the sediment with macroalgae than that without. Multiple linear regression analysis revealed that denitrification in the sediment with macroalgae was limited by the nitrogen substrate, likely due to competition with macroalgae for nitrogen. Temperature and H2S production under macroalgae cover might also affect denitrification. In comparison, the organic carbon content was a key factor regulating heterotrophic denitrification in the sediment without macroalgae. These suggest that the occurrence of macroalgae changes the progress of denitrification in intertidal ecosystems.