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Microbial abundance and activity of nitrite/nitrate-dependent anaerobic methane oxidizers in estuarine and intertidal wetlands: Heterogeneity and driving factors

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Nitrite/nitrate-dependent anaerobic methane oxidation (n-DAMO) is a crucial link between carbon and nitrogen cycles in estuarine and coastal ecosystems. However, the factors that affect the heterogeneous variability in n-DAMO microbial abundance and activity across estuarine and intertidal wetlands remain unclear. This study examined the spatiotemporal variations in n-DAMO microbial abundance and associated activity in different estuarine and intertidal habitats via quantitative PCR and ^{13}C stable isotope experiments. The results showed that *Candidatus* 'Methylomirabilis oxyfera' (*M. oxyfera*)-like DAMO bacteria and *Candidatus* 'Methanoperedens nitroreducens' (*M. nitroreducens*)-like DAMO archaea cooccurred in estuarine and intertidal wetlands, with a relatively higher abundance of the *M. oxyfera*-like bacterial *pmoA* gene (4.0×10^{6}-7.6×10^{7} copies g^{-1} dry sediment) than the *M. nitroreducens*-like archaeal *mcrA* gene (4.5×10^{5}-9.4×10^{7} copies g^{-1} dry sediment). The abundance of the *M. oxyfera*-like bacterial *pmoA* gene was closely associated with sediment pH and ammonium ($P<0.05$), while no significant relationship was detected between *M. nitroreducens*-like archaeal *mcrA* gene abundance and the measured environmental parameters ($P>0.05$). High n-DAMO microbial activity was observed, which varied between 0.2 and 84.3 nmol $^{13}CO_2$ g^{-1} dry sediment day^{-1} for nitrite-DAMO bacteria and between 0.4 and 32.6 nmol $^{13}CO_2$ g^{-1} dry sediment day^{-1} for nitrate-DAMO archaea. The total n-DAMO potential tended to be higher in the warm season and in the upstream freshwater and low-salinity estuarine habitats and was significantly related to sediment pH, total organic carbon, Fe(II), and Fe(III) contents ($P<0.05$). In addition to acting as an important methane (CH_4) sink, n-DAMO microbes had the potential to consume a substantial amount of reactive N in estuarine and intertidal environments, with estimated nitrogen elimination rates of 0.5-224.7 nmol N g^{-1} dry sediment day^{-1}. Overall, our investigation reveals the distribution pattern and controlling factors of n-DAMO bioprocesses in estuarine and intertidal marshes and gains a better understanding of the coupling mechanisms between carbon and nitrogen cycles.