Title:

Evaluating the potential for nitrate reduction through DNRA by anammox bacteria for municipal wastewater treatment

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Abstract:

To shift currently energy-intensive wastewater treatment plants (WWTPs) towards energy neutrality, the implementation of the anammox technology in the mainstream of WWTPs for enhanced nitrogen removal is recommended. However, the lower temperature and ammonium concentration in the mainstream make it difficult to suppress the process disturbing nitrite oxidizing bacteria (NOB), which compete with anammox bacteria for nitrite. In addition, high organic matter content (COD) in the mainstream promotes the growth of the heterotrophs and will lead to the washout of the slow-growing autotrophic anammox bacteria if nitrogen is relatively low (high COD/N ratio). One important discovery besides the conventional anammox conversion (combination of ammonium and nitrite to nitrogen gas) is that anammox bacteria have the capacity to perform dissimilatory nitrate reduction to ammonium (DNRA) with nitrite as intermediate, coupled to the oxidation of volatile fatty acids (VFAs). This pathway allows anammox bacteria to utilize the VFAs in the mainstream and reduce the excess nitrate produced by NOB and/or anammox bacteria itself. The objective of this research is to gain understanding of the DNRA metabolic pathway of anammox bacteria. In this study, batch tests with anammox and heterotrophic bacteria showed the capacity of *Candidatus* 'Brocadia fulgida' to perform the DNRA coupled to the anammox reaction (DNRA-anammox) without prior adaption to VFA. In addition, thermodynamic calculations revealed that low influent COD/N ratios may favour the DNRA-anammox transformation over heterotrophic conversions since more Gibbs free energy is gained per mole of VFA (1984 kJ acetate-mol^{-1} during DNRA-anammox vs. 797 kJ acetate-mol^{-1} during heterotrophic denitrification). Furthermore, we suggest the implementation of an innovative nitrogen removal system in which the nitrate produced by NOB and/or anammox bacteria is converted during the DNRA-anammox pathway, resulting in sustainable nitrogen removal from municipal wastewater in which NOB do not compete with anammox but supply them with substrate.