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Dramatic loss of comammox Nitrospira associated with long-term nitrite feeding

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Until recently, nitrification was thought to be a strict two-step process where ammonia was first oxidized to nitrite by ammonia-oxidizing bacteria and/or archaea, and subsequently to nitrate by nitrite oxidizing bacteria (NOB). Recent studies in NOB metabolism, however, have revealed that certain Nitrospira are capable of performing both steps, resulting in complete ammonia oxidation (comammox) by single microorganisms. These comammox Nitrospira have been detected in drinking water (Pinto et al., 2015; Palomo et al., 2016) and aquaculture systems (van Kessel et al., 2015), as well as deep oil exploration wells (Daims et al., 2015). The discovery of comammox Nitrospira has significantly changed our understanding of biogeochemical nitrogen cycle.

The goal of this experiment was to determine the extent of competition between comammox Nitrospira and canonical Nitrospira in ammonium scarce environment, with nitrite as the main energy source.

Community assembly was monitored on well-established biofilms formed on the grains of rapid sand filter (RSF) for drinking water production. RSF sand was placed in laboratory scale column bioreactors and subjected to continuous feeding of tap water spiked with NO₂⁻ (1 mg-N/L) for 250 days. The biofilms were then characterized by Illumina MiSeq platform, targeting the 16S rRNA gene.

The relative abundance of a putative comammox clade B Nitrospira sequence variant (with 100% 16S rRNA gene similarity to comammox CG24_A assembled genome) identified in the initial RSF sand (Palomo et al., unpublished) at a relative abundance of 12.4±1.1%, was not detected in 4 out of 6 replicates after 250 days. Similar trend was observed for other putative comammox clade B Nitrospira sequence variants. In contrast, we observed significant increase (padj<0.001) in canonical Nitrospira sequences (100% similarity to uncultured Nitrospira sp. clone KC836101 (Pester et al., 2014)).

These observations indicate different behavior of Nitrospira in the absence of ammonia and point to a possible competitive advantage of canonical Nitrospira in environments where nitrite is the sole nitrogen, as well as energy source. In addition, the results suggest that other comammox Nitrospira could also be unable to grow in the only presence of nitrite as it was observed for comammox Ca. Nitrospira inopinata (Daims et al., 2015).