Anaerobic ammonium oxidation (anammox) bacteria and sulfide-dependent denitrifiers coexist in the water column of a meromictic south-alpine lake

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In addition to organotrophic denitrification, alternative pathways, such as anaerobic ammonium oxidation (anammox) or sulfide-dependent denitrification may be important modes for the removal of fixed nitrogen (N) from lakes. We used Lake Lugano as a model system with which to assess possible controls on the concurrence of multiple suboxic N2 production pathways in a lacustrine water column. In the northern basin of Lake Lugano, concentration gradients of dissolved inorganic N toward the hypolimnetic redox transition zone (RTZ) indicate ammonium oxidation and nitrate reduction occurring in close vicinity. Ammonium reaches undetectable levels 15 m below the depth of oxygen disappearance, indicating its anaerobic consumption. The presence of anammox bacteria was confirmed by 16S ribosomal ribonucleic acid gene sequencing. Quantitative polymerase chain reaction revealed a maximum in anammox bacterial abundance at the same water depth where ammonium becomes exhausted. 15N-labeling experiments indicate that anammox activity within the Lake Lugano RTZ can contribute up to , 30% of total N2 production. Incubation experiments with various potential electron donors— glucose, acetate, Mn(II), Fe(II), and H2S—revealed that N2 formation was sulfide-dependent and that organotrophic denitrification is only of minor importance for the elimination of fixed N from the Lake Lugano north basin. Maximum potential rates of anammox and chemolithotrophic denitrification were comparatively low but consistent with nutrient fluxes calculated from concentration gradients. This study provides evidence for the coexistence of anammox bacteria and sulfide-dependent denitrifiers in the stratified water column of a lacustrine environment.
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