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Jensen, Marlene Mark; Ma, Chun; Lavik, Gaute; Smets, Barth F.; Thamdrup, Bo

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Dynamics of N$_2$O production pathways analysed by $^{15}$N/$^{18}$O dual isotope labelling – data from a full-scale wastewater treatment plant

M. M. Jensen**, C. Ma*, G. Lavik***, B. F. Smets**, B. Thamdrup*

* Department of Biology, University of Southern Denmark (SDU), Odense, Denmark, chun@biology.sdu.dk; bot@biology.sdu.dk
** Department of Environmental Engineering, Technical University of Denmark, Kongens Lyngby, Denmark, mmaj@env.dtu.dk; bfsm@env.dtu.dk
*** Max Planck Institute for Marine Microbiology, Bremen, Germany, glavik@mpi-bremen.de

Nitrous oxide production associated with biological nitrogen transformations can contribute substantially to the CO$_2$ footprint of both man-made and natural systems, but the pathways and regulation of N$_2$O production are poorly understood. We developed a $^{15}$N/$^{18}$O dual isotope labelling technique to distinguish and quantify these pathways in mixed communities. The use of $^{18}$O-0$_2$ permits differentiation of hydroxylamine oxidation and nitrifier-denitrification driven N$_2$O production by ammonium oxidizing bacteria. We analysed N$_2$O production pathways during biological nitrogen removal at Lynetten wastewater treatment plant. Under anoxia, N$_2$O accumulated due to denitrification, but N$_2$O accumulation was ~3 and 1.7 times higher at 30 and 100 µM O$_2$, respectively. Oxic N$_2$O production was dominated by nitrifier-denitrification, reaching 73% of the total with the remainder due to hydroxylamine oxidation. Our results demonstrate three active pathways of N$_2$O production, each with different environmental controls. The dual $^{15}$N/$^{18}$O isotope labelling approach can contribute to the development of strategies to minimise N$_2$O emissions from man-made and natural systems.