Surprise: One organism responsible for nitrification instead of two

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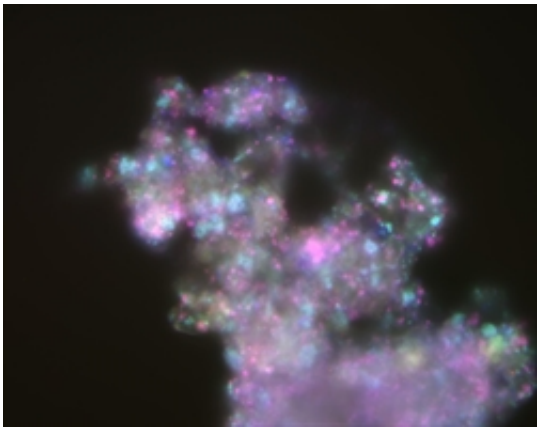


Culture of anammox (pink) and Nitrospira (green/blue) bacteria.

It could never be found until recently, in a fish tank a few floors below Radboud University's microbiology department: one single organism able to perform the complete process of nitrification. Microbiologists used to think that two distinct groups of bacteria were responsible for the stepwise oxidation of ammonia to nitrate via nitrite. *Nature* magazine publishes the results – which have implications on climate research and wastewater treatment – on November 26.

"I noticed something weird in the lab already quite some time ago", Maartje van Kessel, microbiologist at Radboud University, explains. "The nitrogen consumption in my bioreactor seemed to make no sense, it did not match with the microorganisms present in the culture. We saw

enzymes responsible for the oxidation of ammonia, but we could not find any known ammonia oxidizing microorganisms."

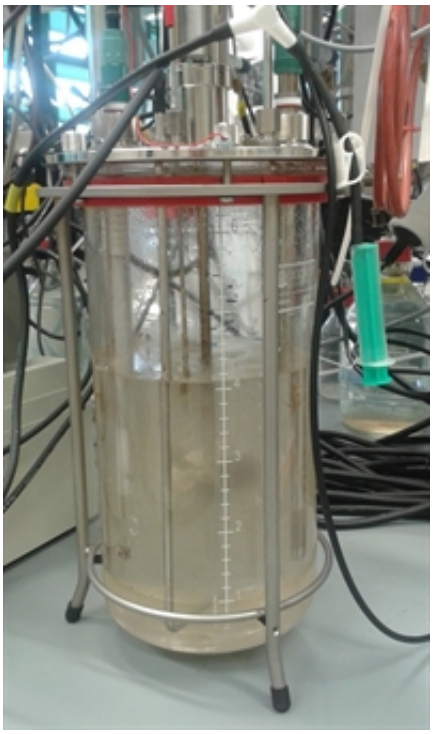
Her colleague Sebastian Lücker adds: "After a while, we were able to link all these enzymes to one single organism. Surprisingly, it belongs to the Nitrospira family which is well known for its ability to oxidize nitrite to nitrate. But it was never linked to oxidizing ammonia to nitrite, the first step in the nitrification process." These new-found characteristics of Nitrospira can help microbiologists and engineers around the world to better interpret the data from their reactors, also in full-scale wastewater treatment plants.

Surprise in the basement

As it turns out, the microbiologist have been sitting on top of the solution to their problem – quite literally. The new characteristics of Nitrospira were discovered in bacteria cultured from biofilters attached to fish tanks at the Animal Physiology research department, located a few floors below the Microbiology department at Radboud University.

Bad guy turns into good guy

The well-known anammox bacteria convert ammonia and nitrite into dinitrogen gas, without using oxygen. Nitrospira was always thought to compete with anammox, by stealing its nitrite away. But with the current discovery, it seems that Nitrospira was actually helping anammox all along by providing it with extra nitrite. A perfect example of a bad guy who proves to be a good guy after all.



Bioreactor with the Nitrospira enrichment.

"Our discovery of this long-sought-after organism will change textbook knowledge, Lücker explains. "I also think it will have big implications for climate research." Nitrogen compounds have a direct and indirect effect on our environment and climate. For instance, they are important fertilizers for plants, but an excess of nitrogen will lead to eutrophication. "We now have a better understanding of the environmental abundance of ammonia-oxidizing microorganisms and the process of nitrification. As a result, global change researchers will have to change their estimations on the nitrification potential in the global nitrogen cycle."

Wastewater treatment

Furthermore, the current finding is of vital importance in processes like

wastewater treatment, where nitrification helps to remove ammonia from the water. Van Kessel: "We already received samples from our wastewater treatment partner, to analyze if this novel Nitrospira is currently active in their systems as well."

During this research, the microbiologists at Radboud University learned of a similar finding by colleagues from Vienna (Austria) – where Sebastian Lücker also completed his PhD research a few years ago. Currently, Lücker is a Radboud Excellence Initiative fellow at Radboud University. "There is a lot of knowledge about Nitrospira in Vienna", he explains. "Right now, both groups are publishing Nitrospira results back to back in the same issue of *Nature*."

More information: Maartje A. H. J. van Kessel et al. Complete nitrification by a single microorganism, *Nature* (2015). DOI: 10.1038/nature16459

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