Microbes emit nitrogen oxides—perhaps more than you think

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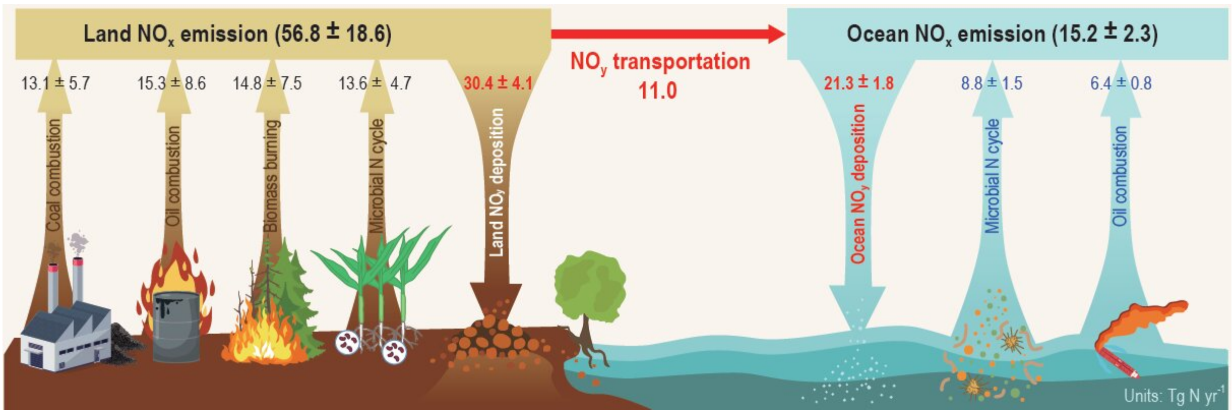

On the left, emission fluxes from major NOx sources and NOy deposition flux in the land atmosphere are seen. On the right, emission fluxes from major NOx sources and NOy deposition flux in the ocean atmosphere are seen. Credit: Wei Song and Xue-Yan Liu

Microbes emit nitrogen oxides, or NO_x. This is important because it involves surface-earth nitrogen (N) cycle, which strongly interacts with environmental quality, food production, biosphere and climate changes. A study led by Drs. Wei Song and Xue-Yan Liu from Tianjin University, China, shows that NO_x emissions from the microbial N cycle account for about 24%, 58%, and 31% of the total NO_x emissions in the land, ocean, and globe, equivalent to 0.5, 1.4, and 0.6 times of the corresponding fossil fuel NO_x emissions. This study fills the data gap of

NO_x emissions from microbial N cycle in the ocean and updates fluxes of NO_x emissions from microbial N cycle in the land and globe. "We confirm the significant contribution of microbial N cycle to global NO_x emissions. It should be considered into current and future atmospheric NO_x emission reduction policy formulation and eco-environmental and climatic effects assessment," Liu says.

Over the past century, atmospheric N loading has become a major driver of air pollution, ozone-layer destruction, elevated N deposition, and associated negative impacts on ecosystem structure and functions (e.g., biodiversity, acidification, eutrophication, and carbon balance).

Nitrogen oxides (NO_x) are major components of reactive N pollutants. Its concentrations and deposition fluxes have been remarkably elevated since the industrial revolution, which has been attributed to fossil fuel NO_x emissions dominated by coal and oil combustion. Recently, non-fossil fuel NO_x emissions from biomass burning and microbial N cycle have been recognized as important sources of atmospheric NO_x. However, due to the incomplete or missing NO_x emissions from the microbial N cycle in the land and ocean, there is great uncertainty in global NO_x emissions. "To accurately constrain global NO_x emissions is pivotal to mitigate NO_x emissions, budget nitrate (NO_3^-) deposition fluxes, and evaluate the eco-environmental and climatic effects of atmospheric NO_x loading," Liu says.

In the land environment, there have been observations and simulations of NO_x emissions from microbial N cycle in natural and agricultural soils. However, it remains challenging to observe NO_x emissions accurately and comprehensively from microbial N cycle from other substrates (e.g., the surface water of rivers, lakes, swamps, etc.) and emission sources (e.g., wastewater, water treatment systems, solid wastes, etc.). In the ocean environment, there are very sporadic observations of NO_x emissions from seawater and thus lack of an estimate on the ocean microbial NO_x emission. Previously, the oil combustion of marine traffic transportation has been considered as the dominant source of ocean NO_x emissions. "Stable isotope methods have been successfully used to trace global water and many other biogeochemical cycles. We need to explore new N isotope methods to comprehensively constrain ocean and land NO_x emissions from microbial N cycle," Song says.

Based on the above issues and background, the nitrogen isotope research team of Tianjin University collected and analyzed the global observation data on nitrogen isotopes of NO_3^- in atmospheric particulates. By using its ocean-land differences, they constrained the nitrogen isotope signals of particulate NO_3^- that were purely derived from ocean NO_x emissions. Furthermore, they constructed a new N isotope method to quantify the relative contributions of major NO_x emission sources by constraining N isotope effects of atmospheric NO_x transformations to particulate NO_3^- and combining the N isotope ratios of NO_x from dominant emission sources, including coal combustion, oil combustion, biomass burning, and microbial N cycle. Then, combining the known fossil fuel NO_x emissions, they accomplished estimates on NO_x emissions from microbial N cycle in the land and ocean, respectively.

The research was published in *National Science Review*.

More information: Wei Song et al, Isotopic constraints confirm the significant role of microbial nitrogen oxides emissions from the land and ocean environment, *National Science Review* (2022). DOI: 10.1093/nsr/nwac106

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