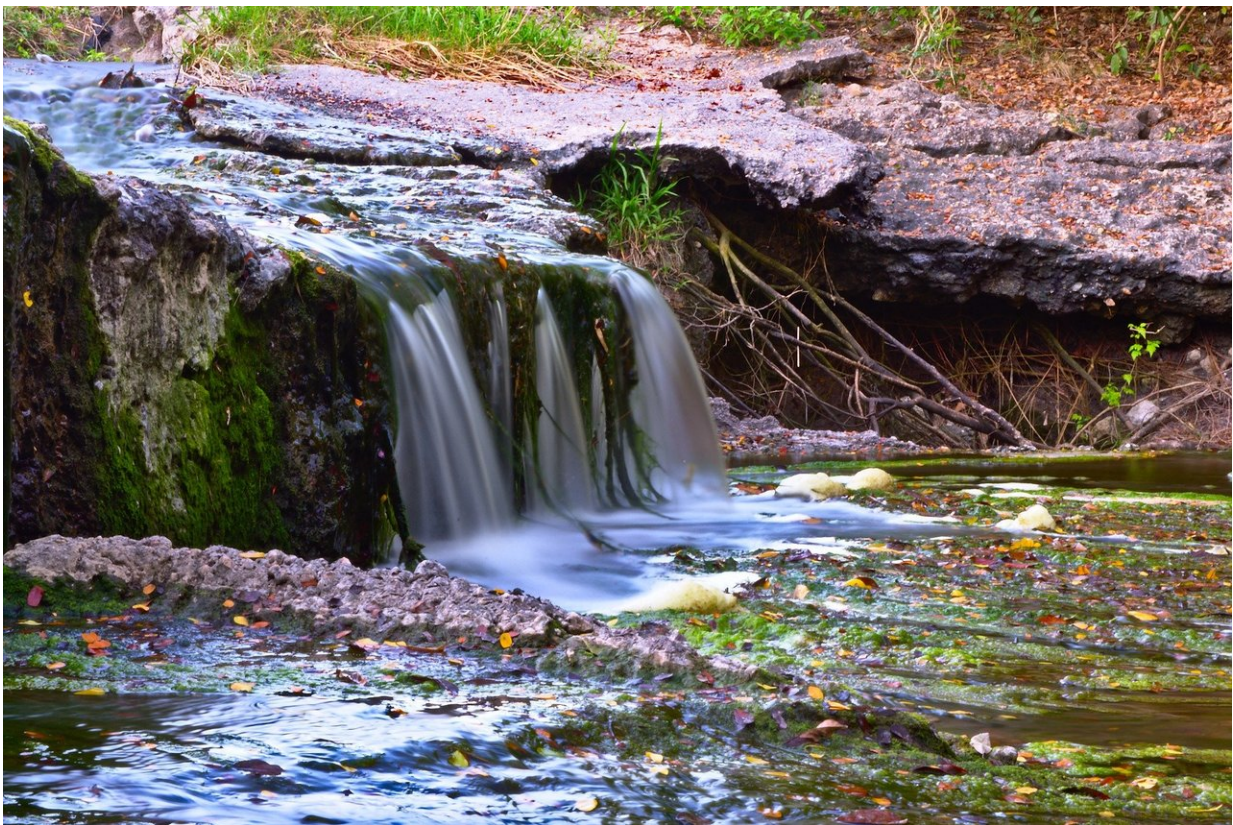


Agricultural runoff contributes to global warming, but a new study offers insight on climate-change mitigation

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Nitrous oxide (N_2O) is a potent greenhouse gas, with 300 times the warming ability of carbon dioxide. Due to fertilizer runoff from farm

fields, an increasing load of nitrogen is washing into rivers and streams, where nitrogen-breathing microbes break some of the fertilizer down into N_2O , which the river releases into the atmosphere as it tumbles toward the ocean. But, until now, scientists haven't had a clear picture of how the process works, what fraction of the runoff winds up as N_2O or what steps might be taken to mitigate N_2O emissions.

"Humans are fundamentally altering the nitrogen cycle," says Matthew Winnick, sole author of a new paper, published recently in *AGU Advances*, and professor of geosciences at the University of Massachusetts Amherst. "We've changed how nitrogen moves through the environment." Much of this change can be attributed to enormous amounts of nitrogen-rich chemical fertilizers, spread upon agricultural fields, which run off into streams and rivers when it rains, and get converted to nitrate.

Scientists have long known that microbes in the soil and streambed contribute to the "denitrification process," whereby nitrate is converted to either harmless dinitrogen gas or N_2O . But the exact mechanics of the conversion processes have remained a mystery, as evidenced by the wide range of N_2O emissions estimates—somewhere between .5% and 10% of global emissions—annually attributable to streams.

Winnick's innovation was to revisit a large experimental dataset that quantified N_2O in 72 streams across the US using a combination of chemical reaction models, which can trace how nitrogen is transformed through a stream system, and stream turbulence models, which capture how the mechanical forces of the river itself deliver nitrate to the stream's bed, which is where denitrification occurs.

This novel combination, pairing the high resolution of the chemical reaction model with the turbulence model, allowed Winnick to see how nitrate moved from the stream to the streambed and was key to his

discovery.

It turns out that what effectively determines the production of N_2O is "denitrification efficiency," or the fraction of nitrate, delivered to the streambed, that is subjected to the various reactions in the denitrification process. The greater the streambed's efficiency in converting nitrate, the less N_2O is released. But where denitrification efficiency is low, Winnick found comparatively higher levels of N_2O emissions.

Furthermore, the bed of the stream to which the nitrate is delivered also plays an important role. Streambeds studded with small anoxic zones, or patches starved of oxygen, also help prevent the release of N_2O .

Winnick suggests that this new understanding of nitrogen cycling could help inform efforts at climate-change mitigation. "Increasing the ability of streams to process anthropogenic [nitrogen](#) may also reduce proportional N_2O emissions," he writes.

More information: Stream Transport and Substrate Controls on Nitrous Oxide Yields From Hyporheic Zone Denitrification, *AGU Advances*, [agupubs.onlinelibrary.wiley.co ... 10.1029/2021AV000517](https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2021AV000517)

Provided by University of Massachusetts Amherst

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