Repairing the Microbial Nitrogen Cycle

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Not everyone can lay claim to having helped found a new field of study or to having a unit of measurement named after them. Kartik Chandran can, but he tends not to. In fact, he'd prefer not to talk about either, except that the subject is very important these days.

Chandran focuses on the influence of nitrogen on global climate and the biosphere. As N_2, nitrogen is a largely non-reactive, but crucial, part of Earth's atmosphere. As nitrous oxide (N_2O), it is one of the strongest greenhouse gases. As nitric oxide (NO), it plays a role in ozone depletion and, at the molecular scale, in promoting resistance to anti-microbial products. Both can be formed in the process of wastewater treatment.

"We'd ideally like to convert everything to di-nitrogen gas," said Chandran. "But if we don't engineer bioreactors well, we'll just end up impairing air quality and possibly creating robust microorganisms."

Ideally, household and industrial wastewater is treated to convert nitrogen-containing compounds to N_2. However, the U.S. Environmental Protection Agency estimates that improper treatment methods lead to the accidental release of 24,000 tons of nitrous oxide in the U.S. alone each year. Because the gas is more than 300 times more effective at trapping heat in the atmosphere, the combined effect is equivalent to having more than one million extra cars on the road.

Nitric oxide is a byproduct of faulty or improper wastewater treatment. In the atmosphere, it converts to nitrogen dioxide, a major component of ground-level smog in cities. It also has the surprising property of helping microorganisms "learn" to become resistant to the human immune system and, potentially, to antibiotics such as tetracycline.

The obvious need for continued treatment of wastewater coupled with increasing concerns over the impacts of improper treatment have led to efforts by Chandran and others to launch the new field of azotomics, which examines the microbial structure and function of the global nitrogen cycle. In addition, Chandran's work has resulted in a new unit of measure, the Chandran number, which describes the propensity of microbes to produce nitrous oxide.

"We are going to be dealing with wastewater treatment and nitrogen pollution for a long time," said Chandran. "By improving understanding of the molecular mechanisms of the microbial nitrogen pathways and coupling that with new engineering tools, we can tackle these issues in a better fashion than we have been thus far."

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