WondN^7

Dave Reay explores the tangled web of nitrogen and global climate change.

Our secondary school chemistry class was not sent wild with excitement the first time we heard about nitrogen. It was spring, and through the dark months of winter the stained and malodorous Mr Davies had dragged us on through the hinterlands of the periodic table. For hour after hour we scribbled down the key facts about hydrogen, helium and the rest and, if we were lucky, got to try out each element's peculiarities in the lab.

We had made hydrogen go 'pop' in a test tube, had been roundly disciplined for breathing in helium from balloons to make our voices squeak, and had burnt some coal to heat water. For nitrogen, though, there was to be no practical. What was there to do with this odourless, colourless and unreactive gas but write down that it was as common as muck and didn't do a whole lot? We had oxygen coming up the following week and the promise of setting things on fire, so for now it was just a case of fidgeting in the clammy plastic chairs and hoping someone would fart to break the monotony.

The key facts on nitrogen were dutifully regurgitated onto exam papers at the end of the year and that, as far as we were concerned, was that. Never again would we have to recall where nitrogen came in the periodic table and all the things it didn't do. I thought nitrogen didn't matter. It seemed irrelevant to the intensifying global challenges of water, food, energy and climate security and that the important things in my life – family, friends and a sustainable future – had nothing to do with nitrogen. On every count, I was wrong.

Fabrice Gouriveau

High-nitrogen wetland, with lots of algal growth.

The 1990s found me as a NERC PhD student aboard a research ship in the Southern Ocean. Our quest was to discover how climate change might affect these vast and violent waters, and almost immediately a glittering strand of nitrogen's key role in life and death began to shine.

Not all nitrogen, I soon became aware, was inert. The cold waters that swirled around the ship were teeming with life that depended on getting enough of the stuff. As I simulated a hundred years' worth of planetary warming in racks of heated water jars, the rampant thirst of all plants and animals for nitrogen, the bursts of growth when it was plentiful and the life-or-death struggles when it wasn't, were played out in miniature before my eyes. It was a revelation – this stuff was actually important. Mr Davies would have been proud.

The stuff of life and death

The more I learned about nitrogen, the more I saw just how powerful it was. From toxic algal blooms in the Gulf of Mexico to eye-watering smogs in Beijing, the harm it did was increasingly obvious. But then so too were its many benefits. When my wife went into labour with our firstborn it was nitrous oxide that eased her pain; when my father was flattened by an attack of angina it was a spray of nitroglycerine into his mouth that had him up and back digging the garden within minutes. In fields around the world nitrogen fertilisers were helping put food in the mouths of billions.

erstuff

This was a substance with myriad forms that had shaped human civilization for millennia and whose fingerprints were all over almost every facet of life on Earth.

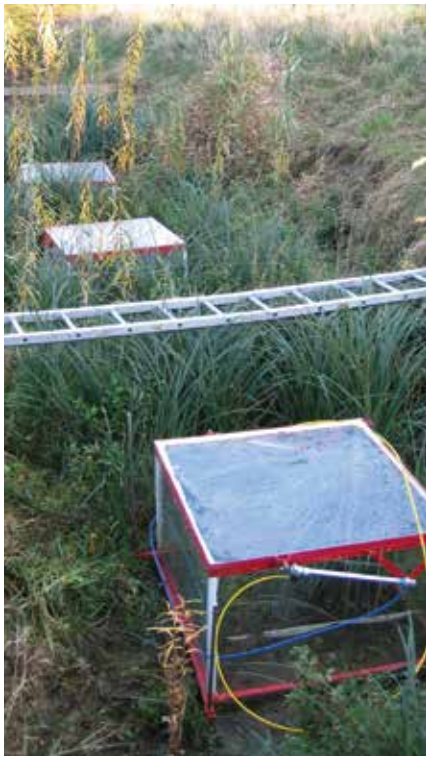
Over the last 20 years my own quest to understand more about nitrogen has become ever more entwined with climate change, and with NERC. From post-doctoral research fellowships examining how nitrogen affects exchanges of the powerful greenhouse gases methane and nitrous oxide, through a NERC fellowship investigating the effects of changing nitrogen use on the climate, right up to today's work on better quantifying emissions of nitrous oxide and other greenhouse gases across the UK landscape, the journey has been both fascinating and alarming.

Our understanding of nitrogen's myriad interactions with climate change is still incomplete, yet the power it can exert for good or ill in a warming world has become all too clear. Each year, agriculture alone introduces around 120 million tonnes of reactive nitrogen directly to the land in the form of fertilisers and nitrogen fixation by legumes. On top of this comes an intensifying shower of reactive nitrogen from the air.

This terrestrial enrichment has many effects on the climate. These range from reinforcing the warming trend through increased nitrous oxide emissions to boosting plant growth and causing natural systems like forests and the oceans to take in more carbon. Its impacts on natural ecosystems are manifold, forming a triumvirate with climate and land-use change as the leading causes of biodiversity loss in the 21st century.

In the world's rivers, lakes and oceans, excess nitrogen can work in tandem with changing temperatures and rainfall patterns to promote harmful algal blooms, exacerbate flood risks and damage water quality. Even in the atmosphere, too much reactive nitrogen can combine with higher temperatures to degrade air quality, pushing up low-altitude ozone concentrations and so threatening the health of plants, animals and humans.

Scratch the surface of the global challenge that is climate change in the 21st century, peer further into the perfect storm of population growth, food shortages and water pollution, and it is the layered and interconnected threads of nitrogen that shine through. They run through life, death and decomposition, integral to our genes, the food we eat, the air we breathe and the climate changes we face. Its story is of the peculiar and the mundane, of water turning red and people turning blue, one of climate friend and pollution foe, of meaty feasts and looming famine. Truly, it is a wonderstuff.



Automated chambers at work measuring nitrous oxide emissions from a farm drainage ditch.

Dave Reay is professor of carbon management at the University of Edinburgh. This article is adapted from his new book *Nitrogen and Climate Change: An Explosive Story* published by Palgrave Macmillan.

He gained his PhD as a NERC CASE student with the British Antarctic Survey and the University of Essex. He was a NERC research fellow between 2005 and 2008 and has worked on numerous NERC programmes including the EDGE and GANE thematic programmes and, most recently, the NERC GREENHOUSE programme.

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