BGS blogs

Tracking nitrate and ammonium in the environment

Newly developed methodologies are improving our understanding of nitrogen cycling.

20/10/2022

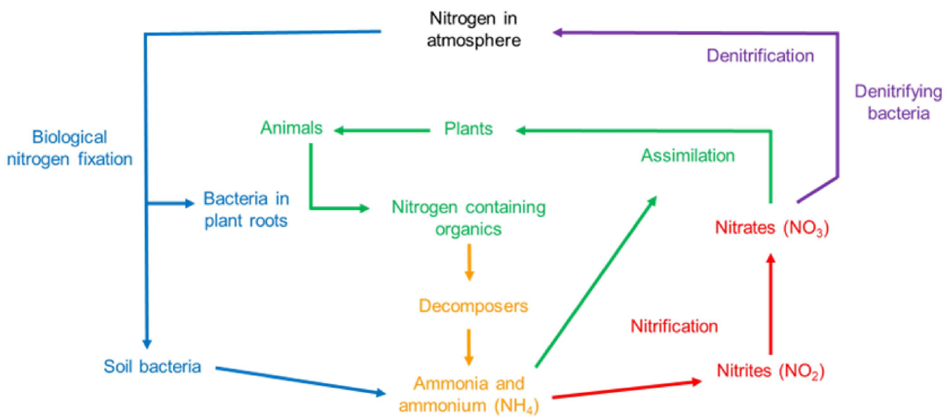
At BGS's Stable Isotope Facility, we are developing a suite of laboratory methodologies to analyse the key nitrogen-bearing species nitrate and ammonium. These methods will allow much lower concentration samples to analysed, helping improve our understanding of nitrogen cycling within the environment.

The nitrogen cycle

Alongside carbon and phosphorus, nitrogen is one of the key micronutrients critical to all life on Earth. It is a core component in amino acids, which, in turn, form the building blocks of all genetic material: DNA and RNA.

Nitrogen is the most abundant gas on Earth, making up 78 per cent of the air we breathe. Atmospheric nitrogen is converted by bacteria in the soil to ammonium (NH_4^+), in a process called nitrogen fixation. From here it is converted to nitrite (NO_2^-) and nitrate (NO_3^-), which can be taken up by plants, thus entering the food chain.

In addition to natural nitrogen fixation, humans apply nitrogen-rich fertilisers to soils to reduce natural nitrogen limitation and promote crop productivity.



The nitrogen cycle, showing nitrogen fixation from nitrogen in the atmosphere to ammonium and the conversion of ammonium to nitrate before it is taken up into plants. Denitrification is the main process by which nitrogen is then lost back into the atmosphere. BGS © UKRI.

This application of fertilisers can have negative consequences. When nutrient-rich water runs off arable land and enters surface waters, for example lakes or rivers, it can promote uncontrollable algal growth. This can drastically decrease water quality, reducing the water's oxygen content and leading to the death of aquatic species. Additionally, high concentrations of nitrogen can enter groundwater, from which it is almost impossible to remove, polluting aquifers that are traditionally used for water extraction and human consumption.

It is therefore critical that we understand how nitrogen enters our most precious environments, how it is cycled, transformed between different nitrogen species and released back into the atmosphere. To understand these processes, we need effective 'tracers'. One of these is the stable isotope composition of nitrogen within different key molecules, including nitrate and ammonium.

Excess nutrients such as nitrogen can cause significant problems with ecosystem health, including the growth of algae and the removal of dissolved oxygen in water, which leads to fish deaths. © Andy Marriott (BGS).

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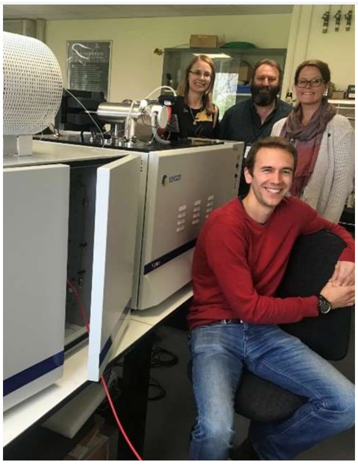
oxygen in water, which lead

New methods

The Stable Isotope Facility has carried out stable isotope analysis of nitrate and ammonium for many years. Traditional methods convert dissolved nitrate or ammonium to a solid, for example silver nitrate, allowing for the combustion of this solid within an elemental analyser coupled to a mass spectrometer. However, these methods required large volumes of sample water (more than 1 l) and high concentrations of either nitrate or ammonium. This used to limit the types and numbers of samples we could realistically analyse.

Recently, we have been working to improve in line with recent published methods. These new methods are up to a thousand times more sensitive than our old procedures, meaning we can analyse much smaller volumes of samples (1 to 4 ml) and at much lower concentrations (less than 1 mg^{-l}). Unlike our old methods, these new techniques convert the dissolved nitrate or ammonium to nitrous oxide gas, which is then analysed by our trace gas and mass spectrometer system (Sercon Cryogas HS2022). This new mode of analysis has needed a lot of setting up and testing over the past year, but we are now getting great data for low concentration nitrogen species.



The Sercon and BGS team, who developed the Cryogas system currently used for N_2O and other trace gas stable isotope analysis at BGS. BGS © UKRI.

The hope is that this faster, cheaper and more sensitive analysis will promote more wide-ranging nitrogen cycling studies using stable isotopes, helping to answer some of the key questions surrounding nitrogen pollution and sustainable fertilisation.

Acknowledgment

Thanks goes to the BGS Innovation Fund and Sercon for supporting this work.

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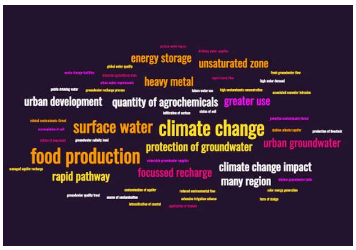

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