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RESEARCH HIGHLIGHTS

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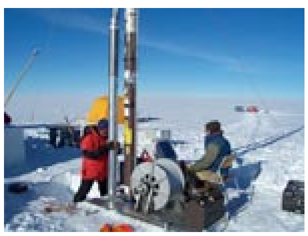
Ice core reveals nitrogen secrets

Over the past 150 years, the nitrogen cycle has changed significantly – fossil fuel burning has increased nitrogen oxide emissions to the atmosphere and the creation of artificial fertilisers has fixed nitrogen gas from the air. Now a team from Brown University and the University of Washington in the US has measured isotopes in nitrates in an ice core from Greenland to find out more about man's impact and the sources of the nitrate.

Processes such as fossil fuel burning, lightning, biomass burning, microbial processes in soils and forest fires create nitrogen oxides, NO and NO_2. These compounds can deposit as atmospheric nitrates (HNO_3 or NO_3^-).

"The nitrogen isotopic composition of nitrate formed in the atmosphere has been suggested to contain information about the sources of nitrate," Meredith Hastings of Brown University told **environmentalresearchweb**. "However, it has been difficult to prove this directly for several reasons: many records are a combination of nitrogen signals, not atmospheric nitrate deposition alone; after the nitrate is deposited it can undergo processing such as biological processing or physical or chemical changes that can alter the original signal; and/or the isotopic signatures of the different atmospheric nitrate sources are not well quantified."



Drilling an ice core in Greenland

According to Hastings and colleagues, lake sediment records indicate that the nitrogen isotopic signal of total nitrogen has decreased since the 1950s as a result of manmade activity. But these records include other forms of nitrogen as well as atmospheric nitrate. So the team turned to the ice core record, which contains atmospheric nitrate trapped in air bubbles, as a potentially more reliable source of information on changes in the nitrogen cycle.

"There are several processes that can modify the isotopic signals captured in polar ice," said Hastings. "However, over the last 300 years we would not expect any of those processes to have changed significantly. What has changed significantly is that we have added a new source of nitrogen oxides to the atmosphere, namely fossil fuel combustion (e.g. coal burning, vehicles, industrial processes)."

The team found that during the last 300 years the nitrogen isotope composition $\delta^{15}N$ decreased from pre-industrial values near 11 per mil to significantly lower levels in the last decade. This decrease was strongly correlated with fossil fuel emissions estimates since 1750. While the nitrate concentration record begins to show a clear rise in about 1890, $\delta^{15}N$ shows a noticeable change as early as about 1850, say the researchers.

"This is the first archived record that clearly shows a change in the isotopic composition of nitrate that cannot be explained except by a significant change in the source of atmospheric nitrate," said Hastings. "[This means] that it should be possible for us to use the isotopic composition of nitrate to quantify the sources that contribute to nitrate deposition."

Being able to know more about sources in this way would help out those studying both today's and past environments. For example, Hastings says it could help determine the sources contributing to acid rain – of which nitric acid (HNO_3) is a major component – and sources that are leading to increased nitrate deposition, which has led to over-fertilisation and eutrophication of some coastal zones. This could help focus action on reducing the impact of the sources that are contributing most to the problem.

"In terms of past environments, we can use, for example, ice core records to look at how natural sources of atmospheric nitrate have varied over time with changes in climate – and this may help us understand how natural sources will change in the future and/or how the environment will behave with changes in atmospheric nitrate," said Hastings. "These are all areas I'd like to explore in my research."

Hastings is also developing methods to capture nitrogen oxides, the precursor of atmospheric nitrate, and measure their isotopic signatures to look at their impact on nitrate deposition. "Nitrogen oxides have a direct impact on air quality through their role in the production of smog," she said. "This new methodology might allow us to distinguish the sources of nitrogen oxides locally and determine whether local sources or the transport of pollution from outside this locale are responsible for changes in air quality."

The researchers reported their work in **Science**.

About the author

Liz Kalaugher is editor of **environmentalresearchweb**.