PROJECT UPDATE

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New York State Energy Research and Development Authority

Environmental Monitoring, Evaluation, and Protection Program

NYSERDA
New York State Energy Research and Development Authority

Quantifying Atmospheric Nitrogen Sources with New Stable Isotope Techniques

Principal Researchers

CAROL A. KENDALL
DOUGLAS A. BURNS
EMILY M. ELLIOTT
U.S. Geological Survey

ELIZABETH W. BOYER
University of California, Berkeley

PROJECT PARTICIPANTS

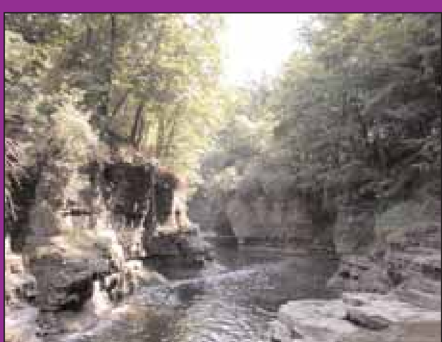
Richard G. Carlton
Electric Power Research Institute

Thomas J. Butler
Cornell University

Greg Michalski
University of California, San Diego

Project Location

Statewide



Credit: E.W. Boyer

Fall Creek, in the Finger Lakes region of New York.

Contact Information

For more information on this project see:

http://www.nyserda.org/programs/environment/emep

or contact Ellen Burkhard at: egb@nyserda.org

Keywords

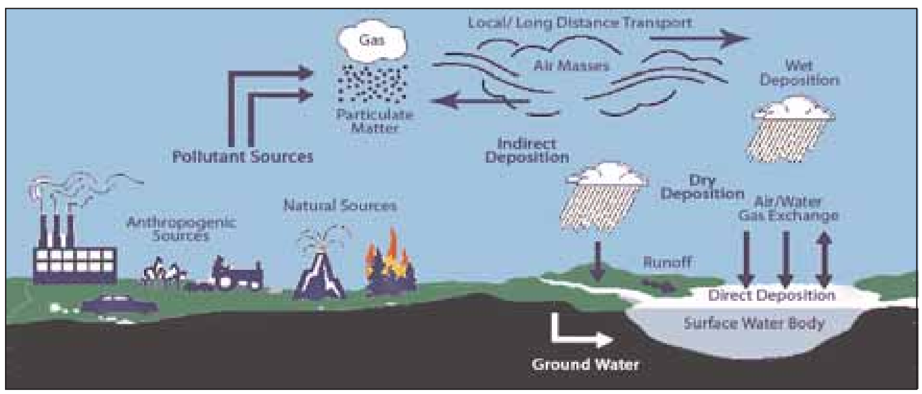
- Acid deposition
- Atmospheric nitrogen
- Isotope
- Nitrates
- Source attribution

PROJECT FOCUS

This new study uses novel chemical tracer techniques to assess the importance of atmospheric nitrogen (N) deposition throughout New York. Isotopes of nitrate are used to fingerprint sources of nitrogen in air, precipitation, and surface water samples in New York State. In particular, new methods are being refined to measure three isotopes in the nitrate (NO_3-) molecule: oxygen-17 ($\Delta^{17}O$), oxygen-18 ($\delta^{18}O$), and nitrogen-15 ($\delta^{15}N$). Investigating the feasibility of using this trio of isotope tracers will quantify: (1) the relative contributions of different sources of atmospheric N to precipitation (e.g., distinguishing between stationary, automotive, and agricultural sources), and (2) the relative contributions of different sources of atmospheric nitrate to several New York watersheds.

CONTEXT

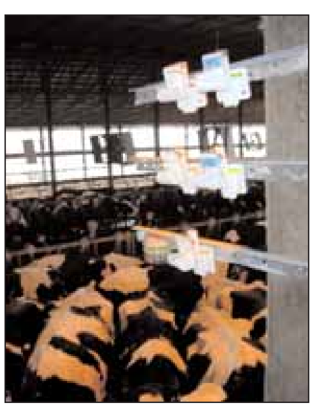
Over the past century, concentrations of reactive nitrogen (available for use by living organisms) in the environment have greatly increased as a result of human activity. The primary anthropogenic sources of reactive N are the manufacture and application of fertilizer, the combustion of fossil fuels, and the production of human and animal waste. The sources of atmospheric N deposition include industrial, automotive, and agricultural emissions. Thus, energy generation and both the production and consumption of food generate reactive N as a byproduct.



Multiple pathways for nitrogen to be present in the environment.

While a certain amount of nitrogen is needed by living organisms and supports higher crop yields and greater energy production, when this amount exceeds what can be assimilated, reactive N released into the environment can degrade air, land, and water resources. In the Northeast, increasing inputs of reactive N have been linked to many environmental concerns, such as forest decline, the acidification of ecosystems, lakes and streams, accumulation of N in groundwater, and eutrophication of waterways.

One method for tracing N sources involves characterizing nitrate isotopes in water samples. Isotopes are atoms of a particular element that have different mass numbers; that is, a different number of neutrons in their nuclei. As emissions from various sources can have different ratios of nitrate isotopes, isotopic composition can provide clues as to the sources of emissions and subsequent reactions.



Recent advances in isotopic techniques provide researchers with powerful tools for quantifying sources of N delivered to landscapes and waterways. New methods for characterizing the $\delta^{18}O$, $\Delta^{17}O$ and $\delta^{15}N$ composition of nitrate requires much smaller sample volumes and less manpower to analyze than previous methods permitted, making it feasible to analyze large numbers of samples.

Photo by E.W. Boyer

Passive dry deposition samplers installed in a confined animal feedlot dairy operation in central New York.

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Credit: E.W. Boyer
Tom Butler preparing the sampling tower at the Clean Air Status and Trends Network Monitoring station at Connecticut Hill, NY.

Project Status

- Initiated 2003
- Project ongoing

New York Energy Smart[SM] Public Service Commission NYSERDA

Since 1975, the New York State Energy Research and Development Authority (NYSERDA) has developed and implemented innovative products and processes to enhance the State's energy efficiency, economic growth, and environmental protection. One of NYSERDA's key efforts, the Environmental Monitoring, Evaluation Protection (EMEP) Program, supports energy-related environmental research. The EMEP Program is funded by a System Benefits Charge (SBC) collected by the State's investor-owned utilities. NYSERDA administers the SBC program under an agreement with the Public Service Commission.

METHODOLOGY

Analysis is being performed on the isotopic composition of (1) wet and dry deposition samples collected within New York's airshed, (2) dry deposition samples collected from various emissions sources, (3) surface water and macroinvertebrate samples from streams and rivers in a variety of environmental settings in New York watersheds, and (4) wet deposition from a national-scale network of sites. Wet deposition of nitrogen occurs during rain and snowfall events. Dry deposition of nitrogen occurs during dry weather conditions through such processes as settling, impaction, and adsorption of atmospheric particles. The sampling has three major components:

- **Nitrogen isotopes in dry deposition sampled from distinct emissions sources.** Passive sampling has been initiated, designed to quantify the characteristic isotopic signatures (δ^{15}N, δ^{18}O, and Δ^{17}O) of "pure" emissions sources (vs.the mixture that is usually present in the atmosphere). Understanding these distinctive signatures will help "fingerprint" precursor sources of N in water and air samples. To date, emissions have been sampled from automotive (car exhaust and parking garage) and agricultural (confined animal feedlot operations) sources. Methodologies to sample industrial emissions from power plants (flue gas) and other stationary sources will be established.
- **Nitrogen isotopes in wet and dry deposition sampled from long-term monitoring networks and from passive sampling.** A national survey of spatial and temporal variations in the isotopic composition of precipitation - i.e., δ^{15}N, δ^{18}O, and Δ^{17}O of nitrate and δ^{15}N of ammonium - is underway using wet deposition data from 156 selected National Acid Deposition Program (NADP) sites. In addition, monthly wet & dry deposition samples are being obtained from several Clean Air Status and Trends Network (CASTNET) sites in New York during 2004-05. Further, a network of passive atmospheric deposition samplers has been set up for sampling dry deposition at several CASTNET and NADP sites in New York, and other locations, in varying land use settings. The isotopic composition from the passive samplers will be compared to the suite of constituents measured by the national network instrumentation in order to assess the utility of passive sampling in identifying atmospheric N sources.
- **Nitrogen isotopes in surface waters.** Monthly to bi-monthly surface water sampling of streams and rivers at six sites in New York was begun, in order to assess the feasibility of using isotopic tracers of nitrate in quantifying contributions of atmospheric and other N sources to streamflow. Results from the monitoring will be compared to several model-derived predictions of N source contributions, using mass-balance and spatial regression modeling approaches.

Credit: E.W. Boyer
Sampling atmospheric emissions from Milliken Station, NY

PROJECT FINDINGS

Preliminary results from New York and other Northeast states show a wide range in both the δ^{15}N values (-7.2 ‰ [parts per thousand] to +4.7‰) and the δ^{18}O values (+47‰ to +90‰). These initial data show interesting spatial and seasonal variations in both δ^{15}N and δ^{18}O. In the winter months, δ^{15}N and δ^{18}O values are generally higher than in the summer months, by approximately 11‰ and 3‰ respectively. The δ^{15}N values for the Northeast states show strong spatial patterns. Median values for δ^{15}N are higher in Pennsylvania, Ohio and New York than in Vermont, New Hampshire and Maine. In contrast, there does not appear to be a similar spatial pattern in δ^{18}O values across these states, with all states showing ranges generally between +70 and +90‰.

PROJECT IMPLICATIONS

Nitrogen pollution is currently increasing in the northeastern United States and contributing to a wide array of environmental problems. Atmospheric N deposition is of particular interest to resource managers and policymakers, as deposition rates in the Northeast are among the highest in the nation. Furthermore, no caps are placed on NO_x emissions, which could increase considerably as population size and the demand for transportation and electricity grow.

Fingerprinting sources of N is critical to current and proposed legislation targeted at the reduction of N inputs to the landscape. For example, the U.S. Environmental Protection Agency (EPA) 1990 Clean Air Act amendments, 1999 Regional Haze Rule, and the proposed 2003 Clear Skies Act all seek to reduce emissions of nitrogen oxides from automotive and electric utility sources through a series of standards, rules, and market-based cap and trade programs. Similarly, EPA's 2002 Concentrated Animal Feeding Operations Rule seeks to reduce N emissions from agricultural sources.

The work underway in this project will provide insight to sources of N in New York's airshed, soils and surface waters. Data regarding the relative contributions of these sources are needed in order to develop sound approaches for managing and understanding the effects of these and other N inputs to the landscape. The findings from this study should improve knowledge of N cycling and enhance our understanding of the impacts of human activities, land management, and environmental policies on N in New York's ecosystems.