Understanding Atmospheric Deposition in Tampa Bay

A public summary document of the Bay Region Atmospheric Chemistry Experiment (BRACE)

What goes up, must come down!

This phrase doesn't apply only to gravity, but to many pollutants and materials emitted to the air that return to the earth over the land and water and contribute to water quality problems. Atmospheric deposition is the process by which pollutants and other small substances are transferred from the atmosphere to the earth's surface. Air pollutants such as nitrogen oxides or sulfur dioxides can return to the land and water as wet deposition (for example, in rainfall) or as dry deposition, which includes both particle dryfall and surface gas exchange.

Harmful substances such as pesticides and chemicals can be emitted into the air, often through aerial spraying, the burning of fossil fuels, or evaporation from the surface. Once in the air, these substances can move with the wind and deposit back onto the earth. Compounds such as sulfur dioxide and nitrogen oxides can react with water in the atmosphere, causing "acid rain." In extreme cases the "acid rain" can cause property damage and harm ecosystems. In the Tampa Bay region, scientists and managers are concerned about water pollution caused by atmospheric deposition.

There are various forms of nitrogen in the environment

Nitrogen is a chemical element with the symbol N. It is found mainly in an inert gaseous state as N\textsubscript{2} and makes up 78% of the air we breathe. Only under special conditions is N\textsubscript{2} converted to a biologically active form. Once converted or "fixed," nitrogen readily combines with other elements to form new compounds. "Fixed" nitrogen is a building block of living organisms. Nitrogen compounds containing oxygen such as Nitrogen Oxide (NO\textsubscript{x}) are called "oxidized" forms, while those without oxygen such as Ammonia (NH\textsubscript{3}) are "reduced" forms. The most common forms of nitrogen discussed in this document are:

- **NO\textsubscript{x}:** Nitrogen combined with 1 or 2 Oxygen molecules
- **NH\textsubscript{3}:** Nitrogen combined with 3 Hydrogen molecules

Atmospheric nitrogen emissions come from natural and anthropogenic sources

Atmospheric nitrogen comes from emissions from both natural and anthropogenic (human-derived) sources. Natural sources include fecal matter from wild animals, forest fires, lightning, oceans, soils, and vegetation. In a densely populated watershed such as Tampa Bay’s, natural sources make up a relatively small component of all atmospheric deposition. Human-derived sources include emissions from fertilizer production and use, human and farm animal waste, and fossil fuel combustion. Of these, the burning of fossil fuels in power plants, industry, and in mobile sources such as cars, trucks, planes, and boats is the largest contributor.
Nitrogen is a pollutant in Tampa Bay

Nitrogen is an important nutrient that is necessary for plant growth. However, too much nitrogen can cause excessive algae growth that can block sunlight necessary for seagrass growth. It can also deplete dissolved oxygen levels, leading to fish kills. Nitrogen enters Tampa Bay through point sources such as direct discharge of wastewater, as well as non-point sources. Stormwater, a non-point source, includes runoff from urban, residential, agricultural, mining, and natural areas.

Goals of BRACE project

Bay area scientists were involved with an air quality modeling and measurement project called the Bay Region Atmospheric Chemistry Experiment (BRACE) from 2002 to 2007. The goals of the project were to:

- Improve estimates of atmospheric nitrogen deposition to Tampa Bay.
- Determine the sources of atmospheric deposition in the local Tampa Bay area and beyond.
- Assess the impact of air quality regulations on nitrogen deposition to Tampa Bay.

Project used air monitors and computer models

This study used a combination of computer models, national emissions data, and local air quality monitoring. The computer modeling system, the Community Multiscale Air Quality (CMAQ) v4.4, simulates how air emissions behave in the atmosphere, including interaction with other pollutants, sea salt (spray), and water. For example, in a cloud, molecules of NOx or NH3 may change from gas to solid particles, then to water-dissolved particles in raindrops that return to the surface as wet deposition. CMAQ simulations of air pollution emissions for the entire continental US provided a broader perspective on the impact to Tampa Bay of nitrogen sources from outside the watershed.

Scientists used high tech instruments to measure meteorology and air pollutant concentrations at six temporary sites across the watershed. These measurements were used to validate CMAQ model performance. Two additional sites, Gandy Bridge Wellfield and Verna Wellfield, hosted long-term atmospheric deposition measurements. The Gandy Bridge site is located in Tampa directly across the bay from the Progress Energy Bartow Plant in northern St. Petersburg. The Verna Wellfield monitoring site is located in Sarasota County, just outside the Tampa Bay watershed. Both locations are noted on the watershed map at the left.

Emissions from outside the watershed are significant

Half of all NOx emissions come from outside the Tampa Bay watershed. Just like there is a Tampa Bay watershed, there is also a Tampa Bay airshed – an area where air pollutant sources contribute to atmospheric deposition in Tampa Bay. The airshed is much larger than the watershed, encompassing almost the entire state and extending into the southeastern US. This means that emissions from places as far away as Atlanta may drift into the Tampa Bay area. Results of this study suggest that half of the NOx emissions measured in Tampa Bay comes from outside the watershed. This means that reductions in emissions on a state-wide or region-wide level could have a positive impact on our local air and water quality.

Nitrogen deposition to Tampa Bay in 2002

Modeling allowed scientists to calculate the total quantity of nitrogen entering Tampa Bay from atmospheric deposition. They began with model-derived average deposition rates across the land and bay portions of the watershed and then calculated the total loading from direct and indirect atmospheric deposition. Loading from point sources such as domestic wastewater and non-point sources including stormwater was calculated from water quality monitoring data collected at facilities or at long-term monitoring stations throughout Tampa Bay.

Mobile sources have a disproportionately higher contribution than power plants to atmospheric nitrogen deposition to Tampa Bay.

Over the bay, NOx emissions from mobile sources were responsible for 4 times more NOx deposition than power plants.

Over the watershed, NOx emissions from mobile sources were responsible for twice the NOx deposition than power plants.
Partnerships formed to manage nitrogen pollution

Managing nitrogen in Tampa Bay is a key goal of the Tampa Bay Estuary Program (TBEP), an intergovernmental partnership devoted to protecting and restoring Tampa Bay. TBEP and its partners in the Nitrogen Management Consortium (NMC) have developed a "nitrogen management strategy" to encourage industries, governments, and citizens in the Tampa Bay area to minimize their nitrogen loading to the bay.

Cities and counties have improved wastewater treatment and expanded use of reclaimed water. Industries have reduced discharges and expanded onsite stormwater treatment. Agricultural operations have installed water-conserving irrigation that reduces fertilizer runoff. And homeowners are helping out by properly disposing of pet waste and by not applying nitrogen fertilizers during summer rains.

Upgrades at Tampa Bay power plants result in better air and water quality

Reducing nitrogen in air pollution is an important element of this strategy. Since 2002, power plants in the Tampa Bay have reduced nitrogen emissions through various initiatives. The Gannon, Big Bend, and Bartow plants installed NOx reduction equipment on their smoke stacks. The Gannon and Bartow plants also converted their facilities from coal-fired, which produces more sulfur dioxide, carbon dioxide, and nitrogen oxides, to natural gas.

Between 2002 and 2010, these power plant upgrades resulted in a reduction of 95 tons of nitrogen through deposition. Air quality monitors in two Tampa Bay counties showed a decrease in NOx concentrations during this period.

National air pollution regulations target fixed and mobile sources

National air quality regulations such as the Clean Air Interstate Rule (CAIR) seek to improve air quality through phased reductions in emissions from both fixed and mobile sources. CAIR regulations address sulfur dioxide and nitrogen oxide pollution in 27 eastern states and the District of Columbia to improve human and ecosystem health. CAIR focuses primarily on power plants that can reduce emissions by installing pollution control equipment, switching fuels, or buying excess allowances from other sources that have reduced their emissions through a cap-and-trade system.

If fully implemented by 2020, CAIR and related federal regulations would remove 7.4 million tons of NOx emissions from all states in the continental US, with 5.7 million tons from states in the eastern US. About 75% of this reduction is from a modernized fleet of on-road motor vehicles. Current federal regulations do not address NH3 emissions, which are expected to grow with increased agricultural demand.

BRACE scientists used computer models to estimate the potential impact of these regulations on atmospheric nitrogen deposition to Tampa Bay and its watershed. Using 2002 meteorology, implementation of CAIR and related federal regulations through 2010 would lead to a 24% reduction of atmospheric nitrogen to the bay. This corresponds to a removal of approximately 430 tons of nitrogen, more than 12% of the total nitrogen loading to Tampa Bay in 2002.

Continued implementation of national air quality regulations may ultimately improve both air and water quality within the Tampa Bay watershed.

Management recommendations for better air and water quality

This study showed that atmospheric deposition is a major source of nitrogen loading to Tampa Bay. Therefore, reducing nitrogen deposition may have a significant impact on water quality in Tampa Bay. Many projects already have been implemented to reduce nitrogen loading from point and non-point sources, but to protect human health and to maintain water quality in Tampa Bay, additional reductions will be necessary to offset new nitrogen loading from population growth in the watershed.

Management recommendations from this study include the following:

- Encourage use of low-emission personal vehicles and public transportation. US EPA cites that driving a car is a typical citizen's most polluting daily activity.
- Support partner actions (e.g., Tampa Bay Nitrogen Management Consortium) related to air quality improvements.
- Re-establish atmospheric deposition monitoring stations within the Tampa Bay watershed to track changes in emissions.
- Develop better monitoring and measurements of direct dry deposition.
- Citizens, industries, and governments all play an important role in reducing air pollution and keeping Tampa Bay healthy and vibrant!

Acknowledgements

The BRACE project was funded by the Florida Department of Environmental Protection.

Technical synthesis was completed by Noreen Poor, Kivmetrics, LLC. noreen.poor@kivmetrics.com

Poor, N.D., Cross, L.M., Dennis, R.L. 2012. Lessons learned from the Bay Region Atmospheric Chemistry Experiment (BRACE) and Implications for Nitrogen Management of Tampa Bay. Atmospheric Environment, in review.

Public summary document prepared by Lindsay M. Cross, TBEP. lcross@tbep.org

Cross, L.M. 2012. Understanding atmospheric deposition in Tampa Bay, Technical report #04-12 of the Tampa Bay Estuary Program. Available at www.tbep-tech.org

Tampa Bay community committed to managing nitrogen inputs