Atmospheric Nitrogen Deposition to the Upper Susquehanna Watershed with Special Reference to Ammonia

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Introduction: Atmospheric deposition to watersheds in the eastern USA, including the Susquehanna Watershed, provides a significant input of nitrogen. Wet deposition estimates are better known, but dry deposition of particles and gases is a much more difficult component to quantify. This study is an attempt to better quantify the total (wet+dry) atmospheric deposition of nitrogen to the Upper Susquehanna Watershed in NY State, and alert people to another major impact not yet quantified.

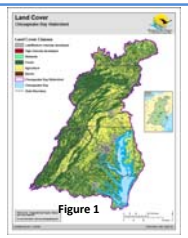


Figure 1

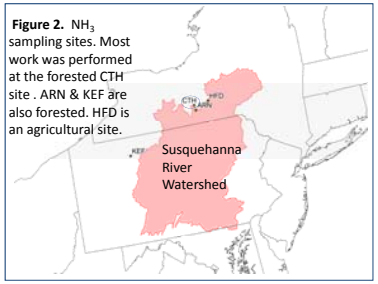


Figure 2. NH_3 sampling sites. Most work was performed at the forested CTH site . ARN & KEF are also forested. HFD is an agricultural site.

Conclusions:

NH_3 average annual air concentrations range from ~0.2 to 0.5 µg NH_3/m^3-yr, and within a year range from near 0 to 1.0 µgNH_3/m^3

NH3 deposition is not nailed down yet. For CTH we estimate 1 to 2.5 kg NH_3-N/ha). For KEF, 0.3 to 1.0 kg NH_3-N/ha.

Total "measured" deposition (including NH_3) is 7.5 to 9.0 kg N/ha-yr for CTH and 7.0 to 7.7 kg N/ha-yr for KEF.

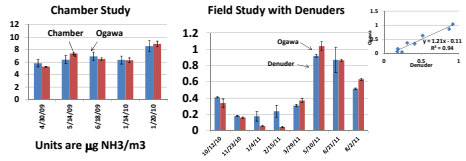
If you include nitrogen species not routinely measured, the deposition would be 9.0 to 10.5 kg N/ha-yr for CTH and 8.5 to 9.0 kg N/ha-yr for KEF

Atmospheric N represents 25% to 30% of the total N coming into the watershed from anthropogenic sources.

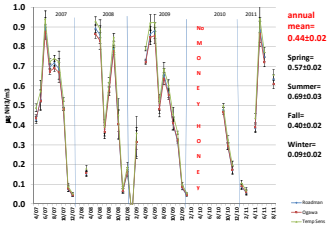
Air, water, landscape and quality of life in the Susquehanna Watershed will be significantly impacted by Natural Gas industrialization… It's just starting.

Measuring NH_3 air concentrations with passive samplers

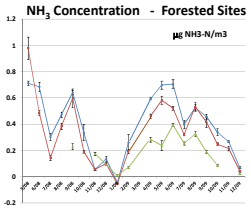
A Chamber Study with a known concentration of NH_3 was used to test the validity of the Ogawa passive samplers. The passive samplers were also compared with active denuder samplers (considered the "gold standard" for NH_3 measurements) in the field over the course of year at CTH (Fig. 2). There was close agreement with the known NH_3 concentration and the passive samplers, and the denuder measurements of NH_3 and the passive samplers.



NH3 concentrations over several years at CTH (see Fig. 2), based on mainly bi-weekly collection periods, show a similar seasonal pattern. The mean annual value is 0.44 ±0.02 µg NH_3/m^3 , which is a low concentration compared to many other areas of the country.



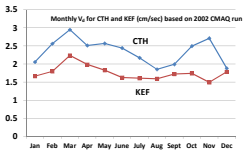
Concentrations of NH_3 are comparable at ARN (13 km from CTH), and lower at KEF (200 km WSW from CTH)(Fig.2). EPA's CMAQ deposition model predicts the lowest values in the watershed in the KEF area. The similarity of these sites suggest a regional pattern of **background NH_3 concentrations with mean annual concentrations between 0.2 to 0.5 µg NH_3/m^3.**

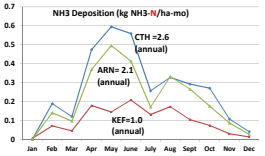


The leap from NH_3 concentration to NH_3 deposition

Ammonia concentrations are converted to deposition estimates by multiplication with a deposition velocity (V_d). V_d is the rate a material is deposited to a surface, in this case the rate NH_3 is deposited to a forest.

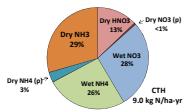
The monthly Vd's below for CTH and KEF are derived from weekly values generated by the CMAQ deposition model.

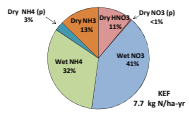




WET & Dry deposition at CTH and KEF

NH_3 deposition represents ~30% and ~13% of the total deposition measured at CTH and KEF, respectively(both are part of NADP (wet) and CASTNET (dry) national deposition networks). Total N deposition measured is 9.0 and 7.7 kg N/ha-yr , respectively.



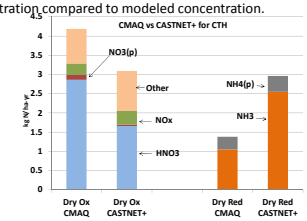


However, NH3 fluxes are bi-directional (bi-di). NH3 emission from soil and plants, as well as deposition, occurs. Bi-di fluxes are in an early stage of development. Initial CMAQ runs using bi-di instead of Vd reduce the deposition of NH3 by 65% and 70% for CTH and KEF, respectively. This gives us a range of NH3 deposition of 1.0 to 2.5 kg N/ha-yr for CTH and 0.3 to 1.0 kg N/ha-yr, using bi-di as low estimate and the Vd for a high estimate. **Total "measured" deposition would then be 7.5 to 9.0 kg N/ha-yr for CTH and 7.0 to 7.7 kg N/ha-yr for KEF.**

Comparison with CMAQ Deposition Model Estimates

There is also **N deposition that is not routinely measured**. Measured and modeled wet deposition compare well. But all dry deposition components are not routinely measured (NOx ($NO+NO_2$), organic nitrates (PAN), N_2O_5, HONO). Our measurements of NOx and "other" oxidized species, measured as excess NOy, agree with modeled deposition estimates at CTH, but HNO_3 deposition estimates do not agree b/c of differing deposition velocities. The difference in reduced nitrogen is due to differences in our measured concentration compared to modeled concentration.

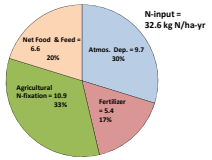
These other oxidized species add another 1.4 kg N/ha-yr. Assuming a similar amount is added at KEF, the **total N deposition estimates are 8.9 to 10.4 kg N/ha-yr at CTH and 8.4 to 9.1 kg N-ha/yr.**

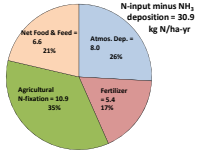


NANI - Net Anthropogenic Nitrogen Input

How much N input to the Upper Susquehanna Watershed is from Atmospheric Deposition?

There is a robust relationship between Net Anthropogenic Nitrogen Input (NANI) to a watershed and the output of nitrogen from rivers such as the Susquehanna River. In the Northeastern and Middle Atlantic US **the nitrogen output is 20% to 30% of the NANI input**.





For the Upper Susquehanna Watershed in New York State, nitrogen inputs from fertilizer, agricultural N-fixation, net food and feed, and atmospheric deposition are estimated to be 30 to 33 kg N/ha-yr. **Atmospheric deposition accounts for 25% to 30% of these inputs**. There have been reductions in atmospheric N-deposition in the last 15 years largely due to reduced NOx emissions from power plants and the transportation sector. Further reductions in NOx (and NH3 emissions) are factors that can further reduce nitrogen loading to Chesapeake Bay. However **there may be new sources of NOx emissions**, VOC emissions etc. exempt from regulation……..

A NEW IMPACT IN THE UPPER SUSQUEHANNA DRILLING FOR GAS IN THE MARCELLUS SHALE

"Finishing a well outside of Dimock PA June 2011 , Photo and FLIR Methane-Tuned Video Courtesy Frank Finan

What the naked eye sees ↑ What IR photogrpahy sees (massive methane release) ↑

A large portion of the Susquehanna River Watershed sits on top of the Marcellus Shale (and the Utica Shale beneath it) which are estimated to hold significant reserves of Natural Gas. Extraction of this gas using **horizontal drilling and high volume hydrofracking (aka FRACKING)** will result in **massive industrialization of the landscape**. 300,000 to 400,000 wells are expected to be drilled in the Marcellus Shale, and 5% of new wells fail. Contrary to what the gas companies say **THIS IS NOT CLEAN ENERGY**. If it is clean energy , why are they **exempt from the Clean Air Act, the Clean Water Act, the Safe Drinking Water Act and the Superfund Act?**

The Nature Conservancy has ranked the Susquehanna River as the single most endangered river in the United States.

This technology has only been used since 2007, starting in Texas and many of the impacts are still unknown, especially in areas with a humid climate. It has largely been used in the arid west. While there is already significant drilling activity in PA the gas companies are just getting started there…..I've run out of room……there is much more to this story.