Acid Rain Trends in New Hampshire Lakes and Ponds

An Overview of Waterbody Response to Acid Deposition-Related Parameters in Three NHDES Monitoring Programs

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Acid Rain Cycle

Effects of Acid Rain

Harmful to fish
- Increase mercury concentration
- Increase inorganic aluminum exposure
- Fatal in high concentrations

Reduces tree health
- Red spruce & sugar maple
  - Growth decline
  - Winter injury

Alters soil
- Leaches base cations (e.g. calcium)
- Mobilizes inorganic aluminum
- Sulfur and nitrogen accumulation
...But now for some good news!

• **Clean Air Act (1970)**
  – Amended 1977 & 1990
    1. Sets standards for SO\textsubscript{2} & other pollutants and requires implementation plans to ensure standards are met
    2. Directs EPA and States to establish air quality programs which set enforceable emissions limits on large pollutant-emitting facilities
    3. Authorizes EPA to set emission standards for motor vehicles and fuels
    4. Set forth provisions to reduce acid rain

• **CAIR/CSAPR (2005)**
  – Cap and trade to reduce power plant SO\textsubscript{2} and NO\textsubscript{x} emissions

• **NH Air Toxics Control Program (1987)**
  – Regulate hazardous air pollutant emissions
In 2011, a scrubber aimed to reduce mercury emissions when online at PSNH (Eversource) Merrimack Power Station. It is also effective at reducing SO$_2$ emissions.
Trend in US Sulfur Dioxide Emissions

Thousand Tons

NHDES Acid Rain Monitoring Programs

**Rooftop Rain**
- Initiated in 1972
- pH, Sulfate, Nitrate

**Remote Pond**
- Initiated in 1981
- Samples collected spring with NH Fish & Game
- pH, ANC, Specific conductance, Sulfate, Nitrate

**Acid Outlet**
- Initiated in 1983
- Samples collected spring & fall (associated with turnover)
- pH, ANC, Specific conductance, Sulfate, Nitrate
NHDES Acid Rain Monitoring Programs

Individual parameters of individual waterbodies

Non-parametric Mann-Kendall trend tests

Significance declared a $p \leq 0.05$

Nitrate: Detection limit 0.05 mg/L. Non detectable results assigned values of 0.025 mg/L to conduct trend analysis
pH Trends in Rooftop Rain at DES

Significant increase

- Average pH
- Median pH
Sulfate Concentration of Rooftop Rain at DES

Significant decrease
Nitrate Concentration of Rooftop Rain at DES

Significant decrease
Are these precipitation trends reflected by our state waterbodies?
REMOTE POND
pH & ANC Example

No significant trend
REMOTE POND
Sulfate & Nitrate Example

Sulfate (SO₄²⁻)
Nitrate (NO₃)
Not detectable

Significant decrease
REMOTE POND
Specific Conductance Example

Significant decrease

umho/cm

Specific Conductance

ACID OUTLET
pH Example

No significant trend
ACID OUTLET
ANC Example

Significant increase
ACID OUTLET
Sulfate Example

Significant decrease

Fall Sampling
Spring Sampling
Summary

Rooftop rain
  – pH increase
  – Sulfate & nitrogen decrease

Remote pond
  – Majority of pH & ANC stable
  – 100% decrease in sulfate & specific conductance
  – Majority decrease in nitrogen

Acid outlet
  – Majority of pH & ANC increasing or stable
  – Greater improvements in Fall
  – ≥80% decrease in sulfate & nitrogen
  – Specific conductance results scattered
Take home messages

• Recovery is occurring but incomplete

• Sulfate concentration in waterbodies has drastically decreased, following reductions in sulfur dioxide emissions

• Long term datasets valuable for trend monitoring
Thanks!

• Dave Neils
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Questions?