Adirondack Long-Term Monitoring Program for Evaluating Changes in Water Quality in the Adirondack Lakes

Karen Roy, Kevin Civerolo - New York State Department of Enviromental Conservation - Ray Brook and Albany - New York 12333
James Dukett, Nathan Houck, Phil Snyder and Susan Capone - Adirondack Lakes Survey Corporation - Ray Brook - New York 12977
Charles Driscoll, Kimberley Driscoll - Syracuse University - Syracuse - New York 13244

Abstract

The Adirondack Long-Term Monitoring (ALTM) Program was established in 1982 to assess seasonal and long-term patterns in the chemistry of lakes in the Adirondack region of New York. The monthly sampling program, initiated with 17 lakes, was expanded in 1992 by an additional 35 lakes considered representative of lake classes across the Adirondacks. In this study, we report the acid-base status of ALTM lakes relative to changes in acidic deposition as a function of different sampling periods. Time-series analyses were performed for 16 unlimed lakes covering the sampling periods of 1982-2000 and 1992-2000 (Driscoll *et al*. 2003) and 48 unlimed lakes during the periods1992-2000 and 1992-2004 (Driscoll *et al*. 2005). Results indicate decreasing concentration trends in sulfates, and increasing trends in acid neutralizing capacity (ANC) and pH. These trends were not necessarily uniform over the monitoring periods. Lake nitrate changes have varied along with pH and ANC but are not explained by nitrate deposition changes. Increases in dissolved organic carbon (DOC) are also detected in a number of lakes. Low levels of pH and ANC with corresponding high levels of toxic inorganic monomeric aluminum (Al_{im}) continue to occur particularly during snowmelt. Year-round levels of Al_{im} remain high in several ALTM lakes. Preliminary results from lakes sampled more intensively during snowmelt indicate that weekly sampling is more efficient at capturing spring depressions in pH and ANC.

Regional comparisons with other sensitive lakes and streams for 1990-2000, found that lakes in the Adirondacks responded similarly to lakes in New England and the Northern Appalachian Plateau with substantial declines in sulfate and base cations and small increases in pH, ANC and DOC (Stoddard *et al*. 2003, Kahl *et al*. 2004).

References

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Jenkins, J., K. Roy, C. Driscoll, C. Buerkett 2005. Acid Rain and the Adirondacks: A Research Summary, Adirondack Lakes Survey Corporation, Ray Brook, NY 12977.

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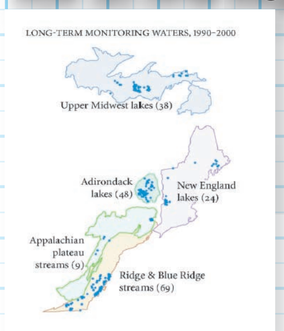
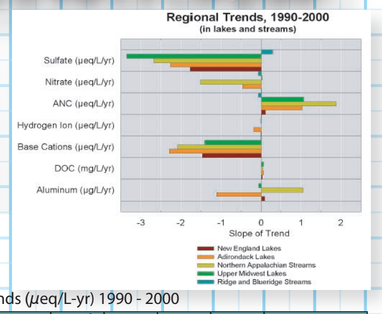
Program History

The ALTM Program was initiated in1982 by Syracuse University, the U.S. Environmental Protection Agency, the NYS Department of Environmental Conservation (NYSDEC), and the Empire State Electric Energy Research Corporation (ESEERCO). This early program sampled the chemistry of 17 lakes in the southwestern Adirondacks and tracked their responses to changes in atmospheric deposition. In 1984, the ALSC was established to determine the extent and magnitude of surface water acidification in the entire Adirondack region. Its 4 year survey of nearly 1500 lakes found deposition-related acidification throughout the region. In 1992, following the enactment of the 1990 Clean Air Act Amendments, the ALSC extended the ALTM project to 52 representative waters in the region. Beginning in 1998, funding for this program was provided by the New York Energy $mart Program (NYSERDA) and NYSDEC. A primary goal of the project is to assess the effectiveness of the 1990 legislation, which mandated significant reductions in emissions of NO_x and SO_2.

How do other Regions of the U.S Compare?





U.S. Trends (μeq/L-yr) 1990 - 2000

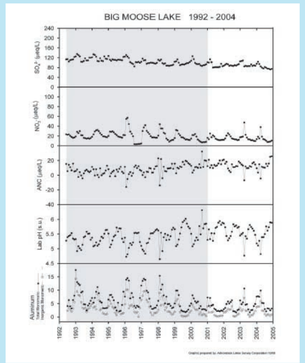
Region	SO_4^{2-}	NO_3^-	C_B	ANC	Reference
Adirondacks	-2.3	-0.5	-2.3	+1.0	Stoddard *et al.* 2003
New England	-1.8	NS	-1.5	NS	
Appalachian	-2.3	-1.4	-3.4	+0.8	
Upper Midwest	-3.4	NS	-1.4	+1.1	
Ridge / Blue Ridge	+0.3	-0.1	NS	NS	

NS - Not Significant

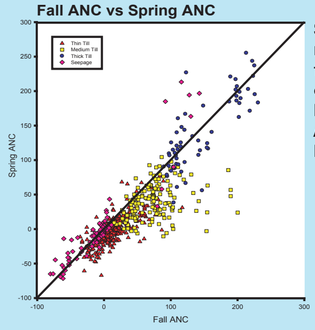
Lake Results 1992 - 2004

Trend analyses (through 2004) show the following changes in lake chemistry in the 48 lakes sampled:

- Overall lake chemistry indicators show improvements, but not neccessarily full recovery.
- Improvement is non-uniform across the region.
- Current measurements indicate many of the lakes continue to show critical levels of pH, ANC and Al_{im}.



Results of Seasonal Kendal Test (SKT) runs for the period 1992-2004 for Big Moose Lake (shaded area is the original 1992-2001 analysis). While sulfates, nitrates and hydrogen ions continue to decline, depressions occur in pH and ANC with associated peaks in aluminum during spring melt.



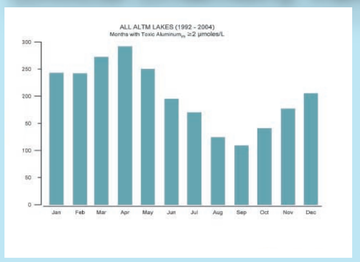
Since 1992, seepage lakes show relatively little ANC depression, the thin till show some. The greatest depressions are in the medium till lakes, with several lakes showing ANC depressed to zero, a critical level for biota.

Time series analyses for 48 unlimed ALTM lakes were conducted from June 1992 through December 2004. Compared to previous analyses through 2000, a greater number of lakes are showing significant positive trends. However, the slopes or rates of those trends have become slower further indicating that full chemical recovery for these lakes will be on the order of decades.

Significant Trends in ALTM Lakes
Values are Mean Rates of Change p < 0.10

Time Period	SO_4^{2-} ↓	NO_3^- ↓	C_B ↓	ANC ↑	pH ↑	Al_m ↓	DOC ↑
1992-2000 (48 lakes)	44 -2.57	15 -1.03	26 -3.33	29 1.60	18 0.04	28 -0.31	7 15.7
1992-2004 (48 lakes)	47 -2.11	22 -0.50	24 -1.62	37 1.13	29 0.02	40 -0.16	12 9.6

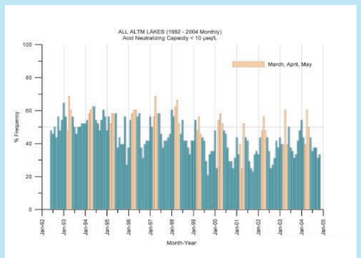
Critical Chemistry Trends and Status of Aluminum in Lakes

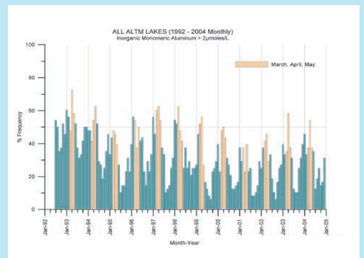


The greatest number of high aluminum values occur during spring snowmelt. The lowest number of occurences is in late summer when flows are lowest with the greatest proportional contribution from groundwater.

Toxic Aluminum Trends in ALTM Lakes

Year	Decreasing Trends	Trend Mean (Range) μmols/L-yr	Lakes with Annual Mean > 2 μmols/L
2000	28	-0.31 (-0.02 to 1.15)	16
2004	40	-0.16 (-0.02 to 0.89)	17





Critically low ANCs and high aluminum values continue to occur more frequently during spring snowmelt.

Adirondack LTM Collaborators

Syracuse University (C.T. Driscoll, K. Driscoll)

U.S. Geological Survey (G. Lawrence, D. Burns, M. McHale)

SUNY ESF (M.J. Mitchell, D. Raynal)

Institute of Ecosystem Studies (G. Lovett, C. Canham, M.Pace)

U.S. EPA Corvallis (S. Paulsen, J. Stoddard)

NYSERDA Environmental Monitoring, Evaluation and Protection Program

NYSDEC Division of Air Resources; Fish, Wildlifeand Marine Resources; and Water Resources

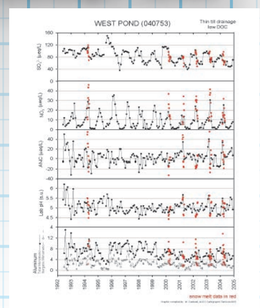
Policy Implications

Time series analysis conducted from 1982 - 2000 and more recently through 2004 show improvements in water chemistry have occurred, albeit slightly, as a result of changes in atmospheric deposition. It is important to note, however, that these data do not indicate that lake recovery is complete, only that it is beginning. Acidic deposition still impacts sensitive ecosystems in the Adirondacks, and at current rates, it will take decades to alleviate acidification stress in these surface waters. In many of the studied lakes, toxic inorganic aluminum levels remain above toxic levels for fish, particularly during snowmelt. And pH and ANC values remain too low for healthy biota. Results indicate further reductions in NO_x and SO_2 emissions would

Snowmelt, Climatic & Hydrologic Factors

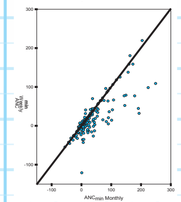
Seasonal acidification is the periodic increase in acidity causing a decrease in pH and ANC. Episodic acidification is caused by a sudden pulse of acids and/or a dilution of bases due to spring snowmelt or large rain events within the year.

Increased nitrate levels are important influences on acid episodes especially when trees are dormant and uptake of N is low. Episodic acidification often coincides with pulsed increases in concentrations of toxic aluminum. These short-term increases can reach levels toxic to fish and other aquatic biota.



The ALTM program began a more intensive spring sampling of 10-12 lakes in 1993. Weekly data are shown in red super-imposed upon the routine monthly (black) data. The weekly data show greater depressions in pH and ANC in almost all spring snowmelt episodes.

Monthly vs. Weekly Snowmelt ANC 1993-2004



Spring snowmelt data show greater ANC depressions than monthly data.

Recent studies show linkages between climatic factors and the dynamics of SO_4^{2-} and NO_3^- in the Adirondacks influencing recovery. The ALTM

Adirondack Lakes Survey Corporation
1115 NYS Route 86 - P.O. Box 296 - Ray Brook - New York - 12977- www.adirondacklakessurvey.org
Voice: 518.897.1354 Facsimile: 518.897.1364

New York State Department of Environmental Conservation
Ray Brook & Albany New York