

Vermont Acid Precipitation Monitoring Program

Data Summary Report 1980-1994 for Underhill and Mt. Mansfield

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Abstract:

The VMC monitoring stations located at Underhill and Mt. Mansfield are included in the Vermont Acid Precipitation Monitoring Program (VAPMP). The majority of bulk precipitation in Vermont is unquestionably acidic. Forty-nine percent of all events occur between the pH of 4.1 - 4.6. Ninety-four percent of all precipitation events have a pH of less than 5.60, the theoretical pH of unpolluted rain. Typically, both sites have lower volume-weighted pH means in the summer than in the winter. Mt. Mansfield, Underhill and a site located in Morrisville were examined for elevational and spatial variations. The sites can be characterized from lowest to highest pH; Mt. Mansfield, Underhill and Morrisville. In addition, a lower pH can be expected on the west side of the Green Mountains due to storm fronts moving west to east.

Introduction:

The Department of Environmental Conservation (DEC) began monitoring precipitation events via the Vermont Acid Precipitation Program (VAPMP). The program was initiated in 1980 to assess the impact of the 1970 Clean Air Act, which mandated the improvement of air quality in the vicinity of midwestern and southeastern fossil fuel burning plants. Precipitation samples are collected on an event basis by dedicated volunteers at six sites throughout Vermont (Mt. Mansfield, Underhill, Morrisville, Concord, St. Johnsbury and South Lincoln).

Methods:

Bulk precipitation is collected and measured on an event basis. Precipitation amount and pH are measured for each event. The pH is measured with a Cole Parmer digital pH meter model 5987 and a Cole Parmer combination electrode with a calomel reference.

Rainfall is intercepted by a funnel with a polyethylene screen (1241 micron mesh) at its vortex and passes through a length of tygon tubing until it reaches and is collected in a one gallon polyethylene jug. The entire apparatus is housed in a wooden box, one foot in width and four feet in height. Snow is collected in a five gallon polyethylene bucket and brought indoors to completely melt before the pH is measured.

The collectors are located in flat open areas, away from roads, point sources, heavily urbanized and/or agricultural areas, trees and overhead wires.

All monitors are trained by the DEC and the monitor's techniques are observed bi-annually. There has been a low turnover of monitors, which has contributed to consistency in the data collection.

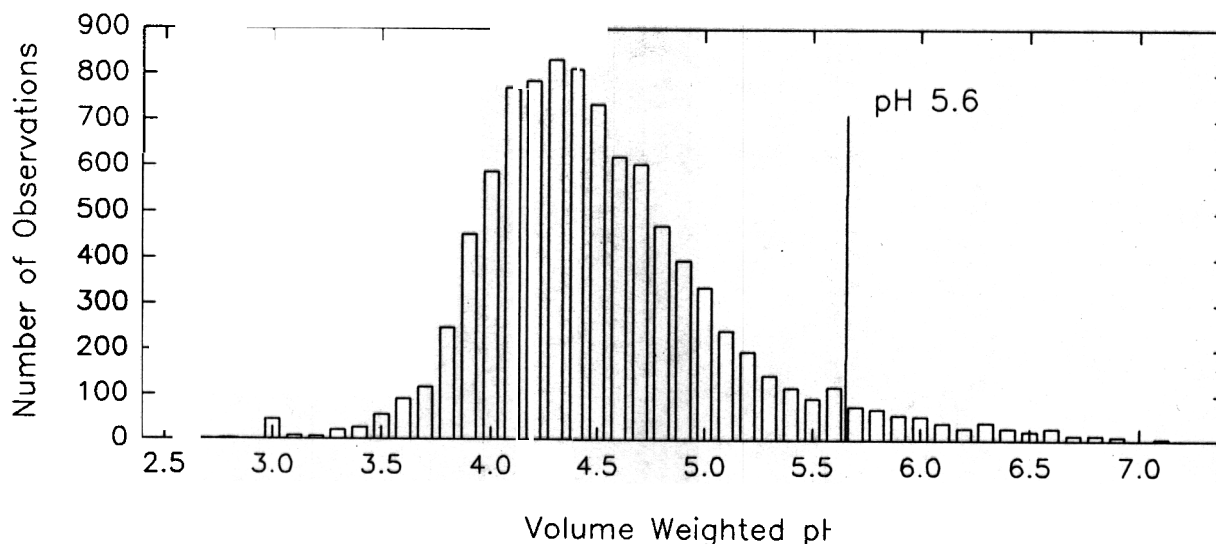
The pH meters are calibrated with buffers 4.00 and 7.00 prior to each use. To ensure that the electrodes are working properly, the monitors are supplied with a check sample of pH 4.70 +/- 0.10 at 25°C. The pH meters are professionally calibrated every year and the electrodes are replaced when they show signs of slow response or failure. The pH and the amount of precipitation is recorded on a monthly report sheets along with comments about duration of event, type of precipitation, time and date of analysis, use of pH check sample and presence of visible contaminants in the sample. The bulk collector jugs and snow buckets are rinsed with distilled water three times after each precipitation event.

Results:

Frequency of Distribution

The highest frequency of precipitation pH occurrence falls between 4.1 - 4.6. Ninety-four percent of all precipitation events from July 1980 to December 1994 are less than pH 5.60, the theoretical pH for unpolluted precipitation. Eighty-five percent of all precipitation events are between 3.00 - 5.00. The most extreme pH observations, both high and low, appear to be associated with low-volume precipitation events while high-volume events tend to have pH's toward the median of the distribution. (Graph 1.)

Graph VAPMP Frequency Distribution for all stations 980-1994
9354 Observations



Mt. Mansfield recorded substantially lower annual volume-weighted pH in 1980, 1981, 1991, 1992 and 1994 (Table 1). In comparison to other VAPMP sites, Underhill and Mt. Mansfield usually have the lowest annual volume weighted pH.

Seasonal Variation

Summer volume-weighted means tend to be slightly lower than the winter volume-weighted means (Table 2). However, there is not a significant trend indicating that the summer means are consistently lower than the winter means.

Table 1. Annual Volume-Weighted Mean pH for 3 Continuously Operating Sites.

SITE	1980	1981	1982	1983	1984	1985	1986	1987
Mt. Mansfield	3.86	4.09	4.28	4.41	4.30	4.35	4.43	4.42
Underhill	ND	ND	ND	4.37	4.29	4.27	4.36	4.32
Morrisville	4.78	ND	4.37	4.51	4.44	4.49	4.51	4.37

SITE	1988	1989	1990	1991	1992	1993	1994
Mt. Mansfield	4.49	4.26	4.28	4.14	4.03	4.25	4.13
Underhill	4.32	4.34	4.46	4.41	4.46	4.28	4.31
Morrisville	4.39	4.44	4.38	4.49	4.64	4.50	4.47

ND = No Data

Table 2. Seasonal Volume-Weighted pH 1981-1994.

SITE	1981		1982		1983		1984		1985		1986	
	W	S	W	S	W	S	W	S	W	S	W	S
Mt. Mansfield	4.32	4.00	4.37	4.25	4.45	4.40	4.21	4.21	4.20	4.24	4.52	4.39
Underhill	ND	ND	ND	ND	ND	4.25	4.44	4.14	4.30	4.25	4.37	4.32

SITE	1987		1988		1989		1990		1991		1992	
	W	S	W	S	W	S	W	S	W	S	W	S
Mt. Mansfield	4.53	4.42	4.38	4.51	4.36	4.29	4.22	4.24	4.32	4.29	3.69	4.60
Underhill	4.40	4.36	4.12	4.23	4.12	4.50	4.35	4.53	4.44	4.50	4.33	4.62

SITE	1993		1994	
	W	S	W	S
Mt. Mansfield	4.24	4.31	4.27	4.14
Underhill	4.25	4.25	4.41	4.19

W = Winter, S = Summer, ND = No Data

Elevational and Spatial Variation

In comparing Mt. Mansfield (3800') with Underhill (1300'), and Morrisville (700') there appears to be a pattern of decreasing pH with increasing elevation. In comparing spatial relationships,

Underhill, located to the west of Mt. Mansfield, has a lower yearly mean weighted pH than does Morrisville, located on the east side of Mt. Mansfield. (Table 1.)

Discussion:

The majority of bulk precipitation in Vermont is unquestionably acidic. However, based on this network there has been no clear trend indicating a statistical change in pH since 1980 in Vermont. It has been suggested that if sulfur emissions decreased, then pH would increase. The VAPMP data does not support this hypothesis. This may be due to the importance of nitrate in atmospheric chemistry, which has not been regulated as strictly as sulfur emissions. In addition, there has been a reduction of base cations in the atmosphere, which provides an atmospherically deposited buffer. This is due in part to the removal of dust particulates from emissions.

Although the summer volume weighted means tend to be slightly lower than the winter volume weighted means, there is no significant trend. In addition, from 1989-1994, summer means appear to be higher than the winter means. In general, a lower pH is expected in the summertime due to increases in sunlight, temperature, humidity and photochemical oxidants which enhance the chemical transformation of sulfur dioxide (SO₂) into sulfuric acid (H₂SO₄) (Allan and Mueller, 1985; Bowersox and Stensland, 1985).

Several spatial relationships have been suggested in reference to precipitation and pH in Vermont. 1) There is a decrease in pH with increasing elevation, mainly due to acidic fog; 2) a lower pH is expected to occur west of the Green Mountains as a result of storm fronts moving west to east, depositing more acidic and concentrated pollutants as they rise over the mountains (Scott, 1987). The VAPMP data support these suggested relationships.

Future plans:

The VAPMP will continue to monitor sites around Vermont with new site(s) being brought into the program. In addition, the Department of Environmental Conservation plans on rigorously testing the data to determine any significant trends.

References:

1. Allan, M.A., and P.K. Mueller, 1985. Precipitation chemistry in the Eastern United States. Air Pollution Control Association 78th Annual Meeting, Detroit, MI.
2. Bowersox, V.C., and G.J. Stensland, 1985. Seasonal variation in the chemistry of precipitation in the United States. Air Pollution Control Association 78th Annual Meeting, Detroit, MI.
3. Schamaun, C., 1994. Vermont acid precipitation monitoring program, data summary report, 1980-1991. Vermont Department of Environmental Conservation, Waterbury, VT.
4. Scott, J.M., 1987. Vermont acid precipitation monitoring program 1980 to 1986 results. Vermont Agency of Environmental Conservation, Waterbury, VT.
5. United States Environmental Protection Agency, 1991. Air and Radiation. Allowance system proposed acid rain rule.