

**Vermont Acid Precipitation Monitoring Program
Data Summary Report 1980-1998 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). For the past 3 years, Mt. Mansfield has provided incomplete data. This was due to two factors: (1) radio frequency interference at the summit and (2) a lack of coordination between collection and analysis of the sample. Initially, problems developed from intense radio frequency emitted from the summit's transmitters. The interference resulted in erratic pH readings. As a result, pH analysis was moved to the base of the mountain and conducted by personnel from Simon Operating Systems. A high turn over of personnel at Simon Operating Systems and problems with coordinating transport resulted in intermittent collection and timely processing. As of June 1999, both collection and analysis will be conducted at the summit with a portable pH meter.

The VAPMP has demonstrated that the majority of bulk precipitation in Vermont is unquestionably acidic. State-wide, forty-three percent of all events occur between the pH of 4.1-4.6, while fifty-three percent of events at the VMC sites are within that range. Ninety-four percent of state-wide precipitation events have a pH of less than 5.60, the theoretical pH of unpolluted rain. At the Mt Mansfield and Underhill sites, ninety-eight percent of all events have a pH of less than 5.6. Overall, Mt Mansfield and Underhill have more acidic precipitation than other VAPMP sites.

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 Vermont Department of Environmental Conservation (VTDEC) began monitoring precipitation events through the Vermont Acid Precipitation Monitoring 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 five sites throughout Vermont (Mt. Mansfield, Underhill, Morrisville, Holland, and St. Johnsbury).

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. The Mt. Mansfield station has an Orion SA 250 portable pH meter with a Cole Parmer combination electrode with a calomel reference. This pH meter was necessary to eliminate electrical interference.

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 melt completely 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 \pm 0.10 at 25EC. 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:

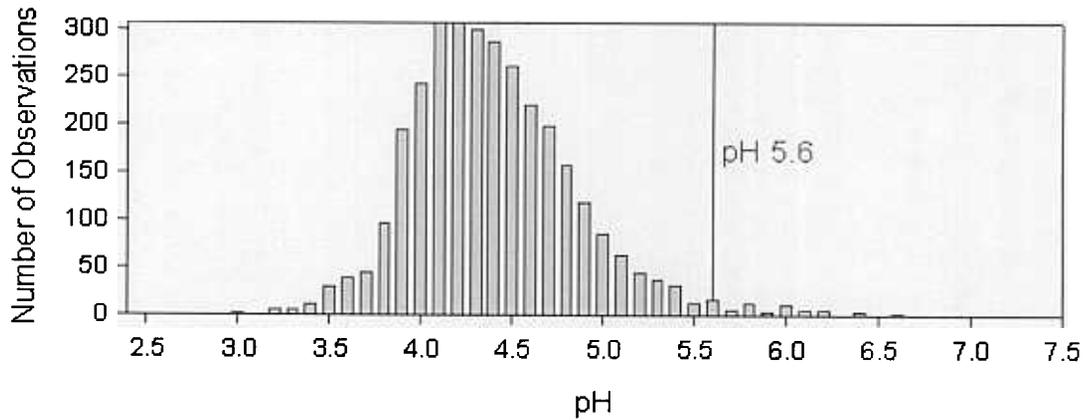
Frequency of Distribution

Fifty-three percent of all precipitation events at Mt. Mansfield and Underhill occurred between pH 4.1 - 4.6. Ninety-eight percent of all precipitation events from July 1980 through December 1998 are less than pH 5.60, the theoretical pH for unpolluted precipitation. 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).

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 typically 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.



Graph 1. VAPMP Frequency Distribution for VMC stations, 1980-1998. 3,180 Observations

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

SITE	1980	1981	1982	1983	1984	1985	1986	1987	1988
Mt.	3.86	4.09	4.28	4.41	4.30	4.35	4.43	4.42	4.49
Underhill	ND	ND	ND	4.37	4.29	4.27	4.36	4.32	4.32
Morrisville	4.78	ND	4.37	4.51	4.44	4.49	4.51	4.37	4.39

SITE	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Mt. Mansfield	4.26	4.28	4.14	4.03	4.25	4.13	ND	ND	3.73*	ND
Underhill	4.34	4.46	4.41	4.46	4.28	4.31	4.38	4.52	4.38	4.42
Morrisville	4.44	4.38	4.49	4.64	4.50	4.47	4.54	4.63	4.47	**

ND = No Data, *= based on incomplete data set **=site closed

Table 2. Seasonal Volume-Weighted pH 1981-1998.

SITE	1981		1982		1983		1984		1985		1986	
	W	S	W	S	W	S	W	S	W	S	W	S
Mt. Mansfield	4.32	4	4.37	4.25	4.45	4.4	4.21	4.21	4.2	4.24	4.52	4.39
Underhill	ND	ND	ND	ND	ND	4.25	4.44	4.14	4.3	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	4.6
Underhill	4.4	4.36	4.12	4.23	4.12	4.5	4.35	4.53	4.44	4.5	4.33	4.62

SITE	1993		1994		1995		1996		1997		1998	
	W	S	W	S	W	S	W	S	W	S	W	S
Mt. Mansfield	4.24	4.31	4.27	4.14	4.38	ND	ND	ND	ND	4.21*	3.63*	ND
Underhill	4.25	4.25	4.41	4.19	4.36	4.36	4.37	4.46	4.39	4.35	4.38	4.51

W = Winter, S = Summer, ND = No Data, *= based on incomplete data set

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. With the implementation of Phase II of the 1990 Clean Air Act, nitrate emissions will be reduced, possibly improving the pH of precipitation. However, Utility Restructuring may have a profound effect on Vermont's precipitation chemistry. Older coal-powered utility plants which were grandfathered in the Clean Air Act may begin to run at full capacity. These plants are able to produce cheap energy without installing pollution prevention devices.

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. Summer data from Mt. Mansfield 1997 was remarkably low. This may be due to incomplete data. 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 and pass over the mountains (VAEC 1984; Scherbatskoy and Bliss 1983). The VAPMP data support these suggested relationships.

Future plans:

As of June 1999, the Mount Mansfield Station is conducting all collection and analysis of precipitation at the summit. Due to the importance of this station, the Program has made considerable effort to continue its operation. Bob Rickner, a WCAX transmitter operator, will be conducting all analyses.

The Morrisville station closed at the end of 1997, and a nearby station was opened in Hyde Park. This station closed in early 1998. We are currently seeking a volunteer in the Morrisville area to continue precipitation monitoring.

References:

Allan, M.A., and P.K. Mueller, 1985. Precipitation chemistry in the Eastern United States. Air Pollution Control Association 78th Annual Meeting, Detroit, MI.

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.

Schamaun, C., 1994. Vermont acid precipitation monitoring program, data summary report, 1980-1991. Vermont Department of Environmental Conservation, Waterbury, VT.

Scherbatskoy, T., and M. Bliss, 1984. Occurrence of acidic rain and cloud water in high elevation ecosystems in the Green Mountains of Vermont. In *Meteorology of Acid Deposition (Transactions)*, P.J. Samson, ed. Air Pollution Control Association Specialty Conference, October 1983, Hartford, CT.

Scott, J.M., 1987. Vermont acid precipitation monitoring program 1980 to 1986 results. Vermont Agency of Environmental Conservation, Waterbury, VT.

United States Environmental Protection Agency, 1991. Air and Radiation. Allowance system proposed acid rain rule.

Vermont Agency of Environmental Conservation, 1984. Vermont acid precipitation monitoring program 1984 update. Montpelier, VT.