Vermont Acid Precipitation Monitoring Program -

Data Summary Report 1980-1993 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-one percent of all events occurs between the pH of 4.20 - 4.60. Ninety-four percent of all precipitation events have a pH less than 5.60, the theoretical pH of unpolluted rain. Both Mt. Mansfield and Underhill have frequent low monthly volume-weighted means compared to the other VAPMP sites. Both Underhill and Mt.Mansfield with a few exceptions, have lower volume-weighted pH means in the summer than in the winter. Mt.Mansfield and Underhill, in addition to one additional site located in Morrisville were selected for the purpose of examining spatial variations. Mt.Mansfield, located at the highest elevation can be characterized as the lowest pH site followed by Underhill.

INTRODUCTION:

The Department of Environmental Conservation (DEC) has been monitoring precipitation via the Vermont Acid Precipitation Monitoring Program (VAPMP) since 1980. The program was initiated to assess the impact of acid precipitation and to assess the 1970 Clean Air Act which mandated improvements in air quality. The pH of bulk precipitation is collected by dedicated volunteers at six sites located throughout Vermont (Mt.Mansfield, Underhill, Morrisville, Concord, St.Johnsbury and South Lincoln). Formally, five additional sites located in Swanton, Canaan, Woodstock, Manchester and West Dover were also monitoring for the VAPMP program. This report is a summary of a previous report for all the VAPMP sites from 1980-1991. The goals of the VAPMP report were to: 1) describe the pH range of bulk precipitation in Vermont 2) evaluate seasonal trends in bulk precipitation pH; and 3) to evaluate spatial differences in pH in relation to elevation and site location. Observations regarding trends and variations have been made predominately without rigorous statistical testing to confirm their significance.

METHODS:

Precipitation is collected in bulk collectors on an event basis with the pH and precipitation amount measured for each event. The pH is determined by a Cole Parmer digital pH meter model 5987 and a Cole Parmer combination electrode with a calomel reference. The U.S. Weather Service provides weather information.

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 area, 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 yearly and the electrodes are replaced when they show signs of slow response or failure. The pH and amount of precipitation are recorded on 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 4.20-4.60. Ninety- four percent of all precipitation events from July 1980 to December 1991 are less than pH 5.60. Eighty-four percent of all precipitation events are between 3.00-5.00.

Mt. Mansfield recorded substantially lower annual volume-weighted pH's in 1980,1981,1991 and 1992 (Table 1). In comparison with the other VAPMP sites, Mt Mansfield and Underhill have frequent low monthly volume-weighted means (Table 2).

Seasonal Variation

Summer volume-weighted means tend to be slightly lower than the winter volume-weighted means (Table 3). There does not appear to be a clear trend indicating that the summer means are consistently lower than winter means.

Spatial Variation

Mt.Mansfield, Underhill and Morrisville are located in too close a proximity to one another to determine any real spatial or elevational variation. However, Mt.Mansfield compared to these sites can be characterized as the lowest pH site.

DISCUSSION

The majority of bulk precipitation in Vermont is unquestionably acidic. Ninety-four percent of all precipitation events from 1980 to 1991 have a pH less than 5.60. The highest frequency of distribution observed was between the range of pH 4.20 and 4.40.

Mt. Mansfield recorded very low annual volume-weighted means in 1980,1981,1991 and 1992. It appears that there has been a slight decrease in the annual volume-weighted means starting in 1991 (Table 1).

Mt. Mansfield and Underhill have frequent low mean monthly pH's compared to the other VAPMP sites. There are two other sites located in West Dover and Canaan with slightly lower mean monthly pH's. However, most observed differences were not statistically significant ($p. < .05$) (Table 2).

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).

Although the summer volume-weighted means tend to be slightly lower than the winter volume weighted means, there does not appear to be a clear trend indicating that the summer means are consistently lower than the winter means. In fact beginning in 1989 through 1993 it appears that the summer means are higher than the winter means. This pattern is

Table 1. Annual Volume-Weighted Mean pH for 2 Continuously Operating Sites

SITE	1980		1981		1982		1983		1984		1985		1986		1987		1988		1989		1990	
	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH
Mt. Mansfield	26.06*	3.86	76.54	4.09	37.52	4.28	54.45	4.41	48.99	4.30	61.42	4.35	67.23	4.43	52.93	4.42	41.26	4.49	68.49	4.26	75.48	4.28
Underhill	Station Not Operating		Station Not Operating		Station Not Operating		35.39*	4.37	40.37	4.29	37.68	4.27	39.59	4.36	41.58	4.32	38.31	4.32	56.11	4.34	62.35	4.46

Table 1. (Continued)

SITE	1991		1992		1993	
	Precip.	pH	Precip.	pH	Precip.	pH
Mt. Mansfield	55.30	4.14	41.01	4.03	62.24	4.25
Underhill	35.88	4.41	32.31	4.46	35.68	4.29

Table 2. Monthly Volume-Weighted pH of Bulk Precipitation at 2 Continuous Sites for the Years 1984-1993.

SITE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mt. Mansfield	4.27	4.26	4.36	4.42	4.38	4.41	4.37	4.24	4.31	4.26	4.43	4.30
Underhill	4.31	4.25	4.44	4.33	4.35	4.39	4.45	4.33	4.43	4.37	4.44	4.31

Table 3. Seasonal Volume-Weighted pH 1981-1993

Site	1981		1982		1983		1984		1985		1986		1987		1988		1989		1990		1991		1992		1993	
	W	S	W	S	W	S	W	S	W	S	W	S	W	S	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	4.53	4.42	4.38	4.51	4.36	4.29	4.22	4.24	4.32	4.29	3.69	4.60	4.24	4.31
Underhill	ND	ND	ND	ND	ND	4.25	4.44	4.14	4.30	4.25	4.37	4.32	4.40	4.36	4.12	4.23	4.12	4.50	4.35	4.53	4.44	4.50	4.33	4.62	4.25	4.25

W = winter; S = summer; ND = no data

suggestive of possible changes in the seasonal distribution of precipitation pH occurring during the latter part of the 1980's. Although no conclusive data exists supporting the change in summer and winter pH, climatic changes could affect the pH. For example, in the past couple of years there may have been more rain than snow events than normal in the winter months, which would possibly have an effect on the recorded winter pH values.

There are several spatial relationships that have been hypothesized in regards 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 in precipitation at sites west of the Green Mountains as a result of storm fronts moving west to east over the Green Mountains and depositing more acidic and concentrated pollutants as they rise and pass over the mountains (Scott,1987). Mt. Mansfield, Underhill and two other sites were chosen to evaluate the relationship between elevation and pH, and to compare the pH east and west of the Green Mountains. The sites located on Mt.Mansfield and in Underhill have similar mean monthly volume-weighted pH values, annual volume-weighted pH values, and seasonal volume-weighted pH values. Mt. Mansfield has a noticeably lower minimum annual volume-weighted pH than the other north central sites, possible due to the higher volumes of precipitation and the regularity with which the site is bathed in acidic fog.

FUTURE PLANS

Continued monitoring by the VAPMP and its dedicated volunteers will provide important information in evaluating the effects and uncertainties of the relationship between the Clean Air Act regulatory implementation and precipitation quality.

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