pH OF MOUNTAIN SNOWFALL IN MONTANA 1981-1984

BY

Phillip E. Farnes[1]

INTRODUCTION

When Mount St. Helens in Washington erupted on May 18, 1980, ash was scattered eastward for several hundred miles (Newell, 1982) and dropped on western Montana's snowpack, which provides most of the water used for irrigation in Montana. Many scientists were concerned that the ash and gases from this eruption and possible future eruptions could create acid deposition. Ash near the volcano had a pH of 6.2 when dissolved in water (Holzey, 1981), and the eruption and fuming after the initial eruption released large amounts of sulphur dioxide (SO_2) into the atmosphere (Newell, 1982). The SO_2 normally oxidizes and combines with moisture to create sulphuric acid available for acid deposition. Acid deposition could reduce water quality and the amount of vegetation on upstream watersheds. Alteration of the vegetation could affect the hydrologic characteristics of these watersheds and the forecast schemes used to predict the runoff.

Since the winter of 1980-81, the Soil Conservation Service (SCS) in Montana has measured the pH of surface snow during the monthly snow surveys. This provides an index of snow pH for comparison with any changes induced by a new eruption.

MEASURING TECHNIQUES

Because funds were limited, the method of measurements needed to be inexpensive. The method also needed to be simple, operable in cold weather, able to measure pH of weakly buffered snowmelt water, and provide data from many widely scattered remote areas.

Nonbleeding ColopHast[2] indicator sticks (0.6 mm X 7.5 mm with the thickness of heavy paper) and small polystyrene tubes (12 mm X 7.5 mm with caps) best satisfied our criteria. Tests at Montana State University Chemistry Laboratory in Bozeman indicated that results with these sticks were consistent and that immersion of the sticks in weakly buffered snowmelt water for about 10 minutes would yield data generally within ± 0.2 units of the pH readings made with a sophisticated laboratory pH meter.

Some variation in the laboratory measurements was noted with sticks remaining in boxes after two years of use. These variations could be related to contamination from opening and closing the lid. New sticks were provided to surveyors every year or every other year to minimize this variation.

By using Colorphast sticks, each snow surveyor could obtain the pH in the field within a few minutes after the snow was melted.

For sampling, the snow surveyors selected an open area away from any apparent contamination, such as pine needles, snow machine or ski tracks. They uncapped a new tube and filled it with surface snow, being careful not to touch the snow or the inside of the tube or cap with their hands or gloves. The cap was used to hold the snow or force it into the tube. The tube was then capped, placed in a shirt pocket, and the snow surveyor proceeded to measure the snow course. By the time the snow course measurement was completed, body heat would normally melt the snow. The surveyors then inserted a ColorpHast stick in the tube and recapped it. After 10 minutes, they compared the color of the stick to a reference and entered the pH value on the snow course notes.

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Snow Survey Data Collection Office Supervisor, Soil Conservation Service, Bozeman, MT.

2/ ColorpHast is a registered trademark. Use of this trademark does not constitute endorsement of implying preference by the U.S. Department of Agriculture.

This quick consistent procedure ensures uniform temperature and exposure to the atmosphere. It therefore provides a better comparison between individual pH readings than if the samples were melted and exposed to the atmosphere for variable times, thereby subject to contamination by micro-organisms.

A pH of 7.0 is considered neutral. A pH of less than 7.0 is acidic, and pH of greater than 7.0 is alkaline. A pH of 5.0 is 10 times more acidic than a pH of 6.0 and 100 times more acidic than 7.0. Rain or snow without impurities has a pH of about 5.6, or the same as distilled water that has been exposed to the atmosphere with normal levels of atmospheric carbon dioxide (Environmental Protection Agency, 1980). There is no general agreement on how low the pH of the snow must be before it should be considered acid deposition. For our studies, snowfall having pH of 4.9 and above would represent "normal" snow and a pH of below 4.9 would represent snow in the acidic range.

ANALYSIS OF DATA

Table 1 summarizes the data from four winters of pH measurements at snow courses in western Montana mountains. The pH was measured at approximately one-half of the snow courses in Montana. Generally, the same group of snow courses were sampled by the same snow surveyors for the four years. Majority of the samples were taken on the March 1, April 1 and May 1 snow surveys. A few samples were also taken with the January 1, February 1, May 15 and June 1 surveys.

During these four years, the number of acidic snow samples varied from 7 to 19 percent of the total. The majority of these snow samples in the 4.0 to 4.8 range occurred in the southwest corner of the state. The one exception was the April 1, 1983, surveys, where many acidic samples were recorded further north into the Upper Clark Fork and Flathead River drainages.

In Table 1, the arithmetic mean was calculated by summing all of the pH values and dividing by the number of samples. The weighted mean was determined by summing the negative logarithm of the pH values and dividing by the number of samples to represent the average of the concentration of hydrogen ions.

TABLE 1

pH OF SNOW SAMPLES AT SNOW COURSES IN WESTERN MONTANA 1980-1984

pH Range	1980-1981	1981-1982	1982-1983	1983-1984	FOUR YEAR TOTAL
4.0-4.2	3	1	6	0	10
4.3-4.5	21	9	34	4	68
4.6-4.8	22	32	71	34	159
4.9-5.1	12	81	85	59	237
5.2-5.4	37	319	290	262	908
5.5-5.7	185	168	101	124	578
5.8-6.0	92	30	5	12	139
6.1-6.3	1	0	0	0	1
TOTAL	373	640	592	495	2100
Arithmetic Mean	5.5	5.3	5.2	5.3	5.3
Weighted Mean	5.0	5.1	4.9	5.1	5.0
Percent Samples in 4.0-4.8 Range	12	7	19	8	11
Mountain Snowpack Status	Below Average	Near Average	SW Near Average Other Below	Below Average	—

There was no major activity at Mount St. Helens during these four winters. At first, we expected that if any areas showed acid snowfall, they would probably appear downwind of large smeltering operations or populated areas in Idaho and Montana. However, the Anaconda smeltering operation in Montana was closed in the summer of 1980, and those in Idaho near the Montana border were curtailed during the summer of 1981.

Western Montana has a few large towns and except for major lumber enterprises in Kalispell, Missoula and Libby, the industries and population probably do not create significant amounts of sulphates and nitrates associated with acid deposition. The state's high-elevation watersheds are predominately forest and range, with some farmland in the valleys.

POSSIBLE SOURCE OF CONTAMINANTS

Since there is little industry or population in southwest Montana, it does not appear that the source of the low pH snow is from the local area. One can speculate that the source of the acid in snow is outside of Montana. Pagenkopf (1983) speculates that five areas could be main sources of acid oxides reaching western Montana. The areas are the Seattle-Tacoma area of Washington, the Portland area of Oregon, the San Francisco Bay area, the greater Los Angeles basin and the Wasatch front in Utah. When the storms cross the mountains of western Montana, the accumulated sulphuric and nitric acids are deposited with the falling snow.

Similar evidence comes from the Air Quality Group at University of California, Davis, which established a Western Fine Particle Network (WFPN) in eight western states in 1979. This network has 40 sampling sites in the Arizona, New Mexico, Utah, Colorado, Wyoming, Montana, North Dakota and South Dakota. Flocchini et al. (1980), analyzed WFPN finding on sulphur concentrations and surface wind trajectories in 1979 and 1980. Concentrations of fine sulphur were significant at sampling locations in Montana even though concentrations were generally greater in Arizona and New Mexico. Cahill et al. (1982) developed maps showing these concentrations of fine sulphur from 1979 through 1981 showing that western Montana was receiving significant levels of sulphur.

Maps from the National Park Service (NPS) Particulate Monitoring Network show large concentrations of fine sulphur in southern California and Nevada as well as Arizona in 1982 and 1983. These maps were prepared primarily from data obtained at national parks or national monuments in the Western United States (Eldred, 1985). Sulphur concentrations in western Montana continued to show significant levels during these two years, similar to 1979, 1980 and 1981.

POSSIBLE IMPLICATIONS

Research by Johnannessen and Henriksen (1978) indicates that about 75 percent of sulphates and 50 percent of the nitrates in the snowpack are leached from the snowpack in the first 30 percent of the melt. They conclude that although small amounts of some materials may be included in solid solution in ice crystals, there are reasons to believe that most of the pollutants are found on the surface of the snow crystals. When there are layers of low pH snow in the snowpack, the pH of water in the early portion of the melt period is much lower than that which occurs near the end of the melt. In drainages having low buffering capacity, this can result in a wave of low pH water and can severely stress fish and other aquatic organisms or even kill them. Acid water can have a severe impact on lakes having low buffering capacity.

Data published by National Atmospheric Deposition Program (NADP) 1982 indicate there are many areas in western Montana where watersheds of high elevation have low buffering capacity and are highly susceptible to acid deposition. These are generally found in the granitic basins or in other basins having neutral soils that have been leached by heavy precipitation. Pagenkopf (1983) has also identified lakes in southwestern Montana that are extremely sensitive to acid deposition.

A National Wildlife Federation (NWF) publication on Acid Rain (1982) identifies acid deposition occurring in the Western United States, which has long been regarded as an area relatively immune to acid rain and its effects. NWF reports that the rain in

Yellowstone National Park is 2-1/2 times more acidic than normal. This publication also indicates that in Glacier National Park, rainfall with a pH as low as 4.4 has been measured at the NADP station established in June 1980.

FUTURE STUDIES

Our studies indicate that acid deposition is being observed in western Montana during winter periods. Since the SCS is not a lead agency in acid deposition monitoring, it is hoped that other agencies such as the Environmental Protection Agency (EPA), Forest Service and Montana Department of Fish, Wildlife and Parks will conduct further investigations. Establishing an NADP station in the higher elevations of southwestern Montana would help monitor year-round precipitation in the area identified by this study as having low pH precipitation. The existing NADP stations at Glacier National Park and Yellowstone National Park are good locations but appear to be too far apart to adequately index precipitation in all of western and southwestern Montana. By monitoring conditions now, before any serious, large-scale problems develop, and identifying possible implications from increased levels of acid snow and precipitation, we hope that Montana and other western states can avoid some of the losses of aquatic life in lakes, dying forests and other problems now appearing in the Eastern United States and Canada.

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