SNOW AS AN ACCUMULATOR OF AIR POLLUTANTS

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ABSTRACT

Using simple analytical techniques, the amounts of air pollutants accumulated in winter snow were determined and the results correlated with lichen survival on trees. Pollutants measured were particulate matter, sulfate, and chloride. An inverse relationship was found between amounts of each of these pollutants and the abundance of various lichens.

INTRODUCTION

Michigan Technological University is located on the south side of a long narrow waterway which bisects the Keweenaw Peninsula, a basaltic and sedimentary rock projection extending about 120 km northeast into Lake Superior. The steep sides of this valley rise abruptly to an elevation of about 120 meters above lake level (183.4m) (Figure 1).

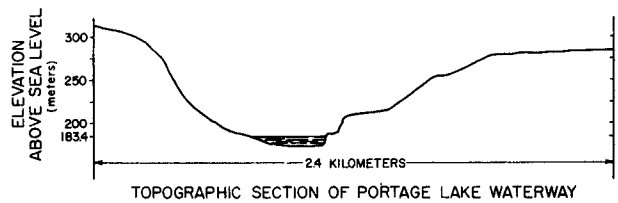

Figure 1. Location of study area. The slope on the right is Houghton where the study was conducted--a north facing slope.

The confined nature of this valley often gives rise to an atmospheric inversion, and the resulting concentration of air pollutants, especially on calm cold winter nights.

The annual snowfall over the past 25 years has averaged approximately 480 cm. This normally comes as gently falling flakes accumulating between one and six centimeters almost every day. As they fall, these flakes acquire air pollutants. In addition, the pollutants settle out and become a portion of the winter snow pack.

METHODS

By sampling the snow in March with a Mount Rose Snow Sampler, I was able to measure the pollution accumulation for the entire winter since the snow does not melt until later in spring. I sampled snow along a line from lake level to 280 m. taking samples at more or less equidistant points close to sugar maple trees. The tree lichen cover was estimated at breast height using a 25 cm × 25 cm flexible square divided into 100 equal sized sub-squares.

In the laboratory, we melted the snow samples and recorded water equivalent depth. After all twigs, leaves, seeds, and other debris were removed we filtered the water to remove particulate matter which consisted primarily of soot and fly ash. The dry weight of this particulate matter was then determined and recorded while the filtrate was evaporated to 20 ml. This was divided into two ten ml fractions; to one, I added a few drops of 1N Ba Cl_2 and to the other a few drops of 1N $AgNO_3$. By filtration, drying and weighing, I determined the weight of precipitates and thus a representation of the amount of sulfate ($BaSO_4$) and chloride (AgCl) which had been present in the atmosphere before falling out in the snow. Evaporation was carried out so that the formation of precipitates during titration would be visible.

RESULTS AND DISCUSSION

Figure 2 shows a comparison of lichen species present on a terrace 30 meters above lake level and at the top of the slope about 100 meters above lake level. Those few found on the terrace were, without exception, tiny and rare while those at the top of the slope were large and abundant as illustrated by Figure 3. The single large source of air pollution was the university heating plant at lake level. (condition now corrected)

Figures 4, 5, and 6 illustrate the inverse relationship between growth of lichens and the presence of air pollutants. Figure 7 shows the relationship between air pollution and remoteness from the primary pollution source. Brown (1974) discusses other aspects of this study.

FIGURE 2
OCCURRENCE OF LICHENS IN AREAS OF LITTLE AIR POLLUTION (TOP OF SLOPE) AND MORE AIR POLLUTION (VALLEY), SPRING, 1974

Lichen	Present on Top of Slope	Present on Valley
Amphiloma lanugionosum (Hoffm.) Nyl.	X	
Cladonia coniocraea (Flk.) Spreng.	X	
Cladonia sp.	X	
Evernia mesomorpha Nyl.	X	
Hypogymnia sp.		X
Lecidia sp.	X	
Lobaria quercizons Michx.	X	
Mycoblastus sanguinarius Norm.	X	
Parmelia caperata (L.) Arch.	X	
Parmelia exasperatula Nyl.	X	X
Parmelia saxatilis (L.) Ach.		X
Parmelia subaurifera Nyl.	X	
Parmelia sulcata Tayl.	X	X
Physcia millegrana Degel.	X	
Usnea comosa (Ach.) Ach.	X	

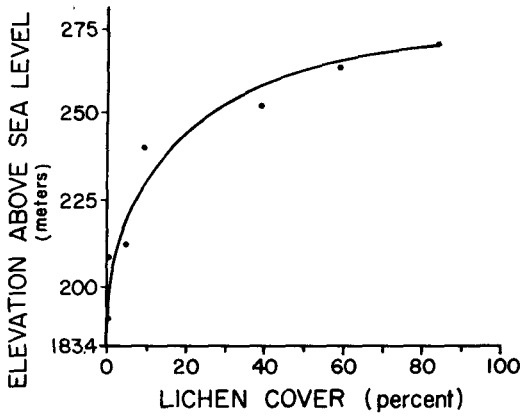

Figure 3. Relationship of lichen cover at breast height on sugar maple trees and site elevation above sea level.

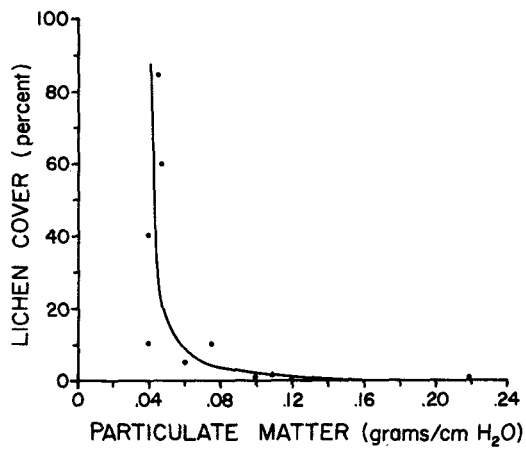

Figure 4. Relationship between particulate matter found in snow and lichen cover on tree bark.

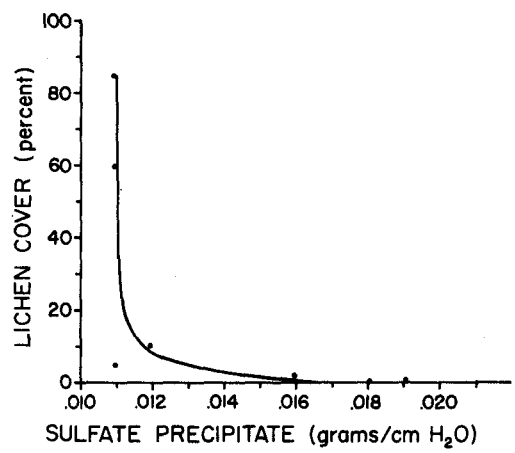

Figure 5. Relationship between sulfate precipitate found in snow and lichen cover on tree bark.

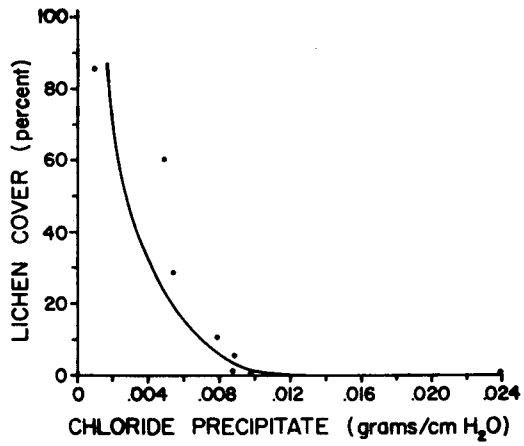

Figure 6. Relationship between chloride precipitate found in snow and lichen cover on tree bark.

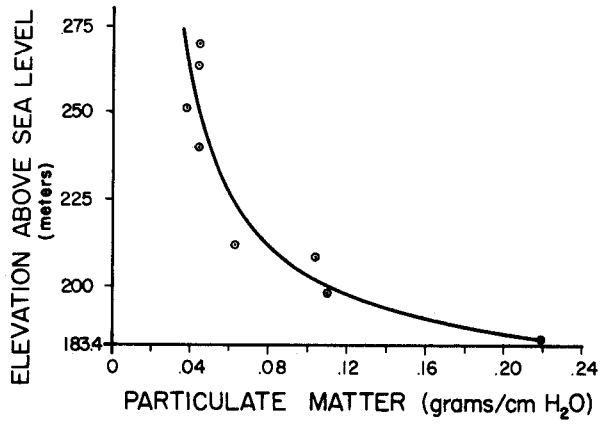

Figure 7. Comparison of amount of particulate matter in air pollutants found in snow and elevation above sea level.

REFERENCE

Brown, R. T. 1974. Furnace fuel, air pollution accumulated in snow and lichen growth on trees. MICHIGAN ACADEMICIAN 7:149-156.