SEASONAL PATTERNS IN ACIDITY OF PRECIPITATION AND THEIR IMPLICATIONS FOR FOREST STREAM ECOSYSTEMS

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Abstract. Data collected since 1965 at a network of nine stations in the northeastern United States show that precipitation is most acid in the growing season (May–September) and least acid in winter (December–February). For the Hubbard Brook station in New Hampshire, where the mean hydrogen ion content of precipitation ranges between 46 μeq l⁻¹ in winter and 102 μeq l⁻¹ in summer, the seasonal pattern in acidity correlates closely with seasonal differences in S deposition from the atmosphere. As summer precipitation passes through the forest canopy, H ion concentrations are lowered by an average of 90%, primarily as a result of exchange with other cations. In winter the H ion content of incident precipitation is lowered from a mean of 50 μeq l⁻¹ to a mean of 25 μeq l⁻¹ during storage in the snowpack.

1. Introduction

Information about the chemistry of precipitation in the northeastern United States has accumulated in recent years to the point where it is now possible to look for trends or patterns. By coupling any discovered patterns with current knowledge of the forest-stream ecosystem, we can more accurately evaluate the ecologic role of precipitation chemistry. In this study, we have attempted to determine seasonal patterns in the acidity of precipitation in the Northeast, and to discuss their implications for the forest-stream ecosystem.

If we assume that the chemistry and acidity of precipitation are the result of in-cloud scavenging and of washout, some reasons for expecting seasonal patterns are obvious. For example, the origins and tracks of major storms often differ by seasons. In turn, the sources of chemicals and the amounts of them that occur in precipitation may be expected to vary with season.

Also, chemicals entering the atmosphere as a result of industrial emissions, residential heating, combustion engines, and other activities may be related to the season. Dusts and organic materials may have greater impacts on the chemistry of precipitation at certain times of the year because of seasonal activities such as farming and construction or the presence of wind-borne pollen or snow cover. And seasonal temperature patterns may have an effect simply by determining whether precipitation occurs as rain or as snow.

The receiving surface also has seasonal patterns that are important to the chemistry of precipitation. For example, growth activities take place in spring and summer, so the potential of precipitation chemistry for stimulation or damage may be greatest during these seasons. Also, the intercepting surface of forests, especially deciduous hardwoods, changes with the seasons and affects the chemistry of precipitation reaching the forest.
floor. Soil moisture patterns are seasonal and can affect the length of time that precipitation is stored in the soil and the extent to which its original chemical composition is changed before it becomes streamflow. Nutrient ions in the forest canopy, forest floor, and soil may be more susceptible to exchange or leaching during certain seasons, depending on biologic activity.

2. Methods

We analyzed data from nine stations in the Northeast for seasonal patterns in acidity of precipitation. Eight of the stations are part of a U.S. Geological Survey (USGS) network located in New York and Pennsylvania (Pearson and Fisher, 1971); the ninth station is at the Hubbard Brook Experimental Forest in central New Hampshire and is operated by the U.S. Forest Service in cooperation with Cornell and Yale Universities. The USGS locations were used only to determine the existence and extent of seasonal patterns in acidity; Hubbard Brook was studied in greater detail for causes and implications of seasonal patterns.

The USGS network began operating in the autumn of 1965, and our study includes data collected through December 1973 (U.S. Department of Interior, 1965–1974). Precipitation samples are composites for monthly periods from collectors which are continuously open to the atmosphere. The collectors were described by Gambell and Fisher (1966); they consist of a straight-sided glass funnel through which precipitation drains into a polyethylene reservoir. A fritted glass disc is attached at the bottom of the funnel for filtration, and the funnel and reservoir are housed in an insulated chest. Techniques for the chemical analysis of precipitation samples are described in Pearson and Fisher (1971).

We began determining the chemistry of precipitation at Hubbard Brook in 1963, but we include here only the data collected from June 1965 through June 1974, the period comparable to available USGS data. Precipitation samples are collected weekly from a polyethylene collector consisting of an uncovered funnel, tubing, and reservoir in summer and plastic trash cans in winter (Likens et al., 1967). The entire system is meticulously cleaned and re-installed each week. In addition to the precipitation data, our paper incorporates information from other Hubbard Brook studies concerning the chemistry of throughfall and stemflow (Eaton et al., 1973), the snowpack (Hornbeck and Likens, 1974a, b), and streamflow. The analytical procedures for all samples collected at Hubbard Brook are those given by Likens et al. (1967) and Fisher et al. (1968) with the exception that automated colorimetric analysis has been used for anion and ammonium determinations since 1972 (Likens, 1972). Hydrogen ion concentrations for both Hubbard Brook and the USGS stations are calculated from measured pH values determined with glass electrodes and electronic pH meters.

We have based much of this paper on the means of monthly values that have been weighted proportionally for amount of precipitation. We determined coefficients of variation together with the means and found that Hubbard Brook consistently had lower coefficients of variation than the USGS stations. For example, the monthly