ACIDITY AND CONDUCTIVITY OF PRECIPITATION ON CENTRAL LONG ISLAND, NEW YORK IN RELATION TO METEOROLOGICAL VARIABLES

GILBERT S. RAYNOR and JANET V. HAYES
Atmospheric Sciences Division, Department of Energy and Environment, Brookhaven National Laboratory, Upton, NY 11973, U.S.A.

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Abstract. Three years of hourly sequential precipitation samples from central Long Island, New York were analyzed to determine the relationships between acidity and conductivity and concentrations of sulfate, nitrate plus nitrite, nitrogen in ammonium, sodium, and chloride ions. Relationships between precipitation acidity and meteorological conditions were also studied.

Hydrogen ion concentrations are similar to those elsewhere in the northeastern United States. They are best correlated with sulfate concentrations but also correlate with concentrations of nitrogen in nitrate plus nitrite and nitrogen in ammonium ion. Concentrations are highest in the summer, with cold front and squall line precipitation and with rain showers and thundershowers.

All ions measured contributed to sample conductivity but hydrogen ion contributed the most with sulfate ion second. Conductivity calculated from concentrations of the separate ions agreed well with measured conductivity. Conductivity showed relationships to meteorological conditions similar to those of hydrogen ion concentration except when sodium and chloride ions predominated in the sample.

1. Introduction

Research in precipitation chemistry has intensified in recent years because of increased awareness of the actual and potential ecological and economic problems caused by 'acid rain'. Recent reviews of these problems in the northeastern United States and Scandinavia were given by Likens and Bormann (1974); Oden (1976); Dovland et al. (1976); Cogbill (1976); and Likens et al. (1979). Information on precipitation composition in the northeastern United States was summarized by Ziegler (1979). An improved understanding of the causes and effects of acidified precipitation is being obtained but adequate documentation of long-term temporal changes has been hampered by lack of adequate and continuous sampling data.

Incorporation of air pollutants into cloud droplets and precipitation is caused by meteorological and chemical processes most of which are poorly understood and difficult to study experimentally. Previous precipitation sampling programs have not usually documented the meteorological conditions of the sampling period. Since samples were collected weekly or monthly in most programs, relating the chemistry of the samples to associated meteorological conditions would not have been possible. Even with event samples which are now collected routinely and usually daily in some programs, only average chemical measurements are available. Studies which considered some meteorological factors were reported by Gorham (1958) and Wolff et al. (1979). Since both the chemical composition of the precipitation and the meteoro-
logical conditions often change significantly during an event, important relationships may be obscured by lack of temporal detail. Thus, collection of short-period samples within events and measurements of concurrent meteorological conditions is a necessary prerequisite for investigating the relationships between precipitation chemistry and atmospheric processes.

Hourly precipitation samples have been taken at Brookhaven National Laboratory (BNL) since June 1976 as part of a larger study of the effects of acid precipitation on vegetation (Evans et al., 1977). A primary purpose of the sampling program is to document changes in precipitation chemistry during events and to relate the changes to causative or associated meteorological factors. Longer range objectives are to determine the mechanisms by which pollutants enter precipitation and to determine the sources of the pollutants.

Statistical analyses of the first year of data and the first two years of data have been reported (Raynor and Hayes, 1978, 1979). A brief description of the program with case studies of several early events was given by Raynor (1979). The purpose of this paper is to report the variations in acidity and conductivity of the hourly samples collected over a three-year period and to relate the variations to concurrent meteorological conditions. Companion papers will present data on the other chemical constituents in the samples in a similar fashion.

2. Methods

Samples were collected with an automatic, sequential precipitation sampler designed and built at BNL (Raynor and McNeil, 1978, 1979). Samples were analyzed for pH, conductivity, and concentrations of sulfate, nitrogen in nitrate plus nitrite and ammonium, chloride and sodium ions using methods previously described (Raynor and Hayes, 1978, 1979). In addition to the chemical measurements, data recorded for each sample included date, sample number, event number, time of beginning and end of sample, duration the cover was open, precipitation amount and type, cloud type, synoptic situation causing the precipitation, wind direction and speed at a height of 108 m, and air temperature. Chemical measurements are reported in micro-equivalents per liter (μeq l⁻¹) for data analysis. pH measurements were assumed to indicate free hydrogen ion concentrations. Excess conductivity was calculated to give a measure of conductivity attributable to constituents other than H⁺. Excess sulfate and excess chloride were calculated to determine the non-seawater contribution of these ions using the SO₄²⁻/Na⁺ and Cl⁻/Na⁺ ratios in seawater to compute the seawater portion. Sodium was used as a reference because the Cl⁻/Na⁺ ratios in precipitation samples are usually above the seawater ratio suggesting sources of Cl⁻ other than the ocean. No other significant sources of Na⁺ are believed present in this area in contrast to some inland locations. Although the Cl⁻/Na⁺ ratio may change as seawater droplets injected into the atmosphere evaporate, the ratio is still a useful reference.

A few cases of probable erroneous measurements and all cases near the lower limit of the measurement capability were excluded from the data base. Many hourly