



## Project Summary

# Acid Precipitation and Drinking Water Quality in the Eastern United States

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Research was conducted to provide accurate, modern, and historical data on drinking water quality and the possible effects of acid precipitation on water samples. Samples of raw source and finished water were collected from more than 270 surface water and groundwater supplies in the New England states, New York, New Jersey, Pennsylvania, West Virginia, Virginia, and North Carolina. The samples were analyzed at U.S. Environmental Protection Agency (EPA) laboratories. The study used historical records dating back to 1886.

Acid rain may dissolve harmful elements from soils and, indirectly, from water supply distribution systems. Causal relationships are difficult to identify, however, because soils can alter the character of acid rain through buffering. A helpful approach to this problem is the use of indices of water supply sensitivity and corrosiveness. Reliable chemical data were used to compare the water supply characteristics with these indices and with drinking water standards.

Although solution products of acid rain do not exceed EPA primary Drinking Water Regulations, in the water supply sources studied, many tests for aluminum showed levels that could be of concern to patients using kidney dialysis. Because of the low alkalinity and pH observed at numerous water sources, it is possible that future acid deposition could have a detrimental effect on water quality. Quantification remains a problem, however.

*This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).*

### Introduction

From 1981 to 1983, the New England Water Works Association undertook this study with a three part program of water sampling and analysis to learn about the quality of drinking water in states receiving acid precipitation. States included in the first and second parts of the study (Rounds 1 and 2) were Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, and New York (Adirondack Mountain region only). States included in the third part (Round 3) were Massachusetts, New Jersey, Pennsylvania, West Virginia, Virginia, and North Carolina.

In addition to the data gathered on present-day water quality, the study also included historical water quality data kept by water utilities, state agencies, and water utility laboratories. Historical data were used to search for water quality changes over time. Present water quality data were compared with water quality standards and were used to calculate water quality indices based on  $\text{CaCO}_3$  solubility, including the Langelier Index, Ryznar's Stability Index, the Aggressive Index, and the Calcite Saturation Index. Many of the waters examined were deficient in alkalinity and calcium,

making it impossible to assign values for pH's, the Langelier Index, and the Stability Index. Nevertheless, these parameters were determined by the Larson Method for pH's so that some approximation might be had of the relative corrosivity of the various supplies with respect to each other and for comparison with the EPA values for corrosivity characteristics as addressed by indices (FR August 27, 1980, p57341). In that document, no exception was made for waters of low alkalinity.

## Study Methods

Field activities were conducted by staff members selected for that purpose. Generally one person was responsible for an entire state. Field staff visited water utilities, gathering data, collecting water samples, analyzing for pH, and preparing water samples for shipment to the Drinking Water Research Division of the U.S. Environmental Protection Agency (EPA) in Cincinnati, where analyses were performed for chloride, sulfate, nitrate, alkalinity, copper, iron, manganese, lead, cadmium, zinc, mercury, calcium, magnesium, aluminum, and other constituents. Samples with and without acid preservation were sent to the EPA laboratory.

Water samples collected included raw source water, finished water at water treatment plants, and household water. The household water samples were collected in the morning before any other use of water. The three household samples were collected to obtain (1) water that had been held in household plumbing overnight, (2) water that had been held in the service line overnight, and (3) water from the water main.

The first two rounds of field activities were conducted in 1981 and 1982, respectively, and included the New England states and New York. Round 3 (1982-83) included Massachusetts (Martha's Vineyard only), the New Jersey Pine Barrens and coastal areas, and the Appalachian Mountain regions of Pennsylvania, West Virginia, Virginia, and North Carolina.

Analytical methods used by the EPA laboratory are described in the full report. They were generally in accordance with *Standard Methods*. Field measurements of pH were made with portable, electronic pH meters and combination electrodes standardized in the field before data were collected. Quality assurance and quality control are described in the full report.

## Basis for Assessing Water Quality

The quality of water sampled and analyzed in this study was compared with that specified by EPA's National Interim Primary Drinking Water Regulations (NIPDWR). The regulations have maximum contaminant levels (MCL's) for health-related substances, including lead (0.05 mg/L), cadmium (0.010 mg/L), and mercury (0.002 mg/L). Secondary maximum contaminant levels (SCML's) exist for pH (range 6.5 to 8.5), copper (1 mg/L), zinc (5 mg/L), and other substances. EPA has no MCL or SCML for aluminum. Concentrations of aluminum measured in this study were compared with the American National Standards Institute limit for aluminum in kidney dialysis water (0.01 mg/L). Water quality indices based on CaCO<sub>3</sub> solubility, particularly the Langelier Index and the Stability Index, have been and are being used by utility personnel to estimate whether water would deposit or dissolve CaCO<sub>3</sub> and cause corrosion. The ability of these indices to predict corrosion is limited, however. The Calcite Saturation Index has been used by acid precipitation researchers to assess the susceptibility of surface waters to acidification.

## Results

Table 1 lists the number of raw and treated water samples analyzed for cadmium, lead, and mercury, and the number of samples equal to or exceeding

the MCL's. The MCL was exceeded by cadmium in 1 of 484 samples, by lead in 5 of 483 samples, and by mercury in 2 of 484 samples.

The pH of both raw and treated waters often fell outside the 6.5 to 8.5 given as the SMCL. One fifth or more of the raw and finished waters from surface and ground sources fell outside this range in Round 1. About half of the raw waters sampled in Round 2 had pH values below 6.5. Fewer than half of the treated waters in Round 2 fell outside the SMCL range for pH. In Round 3, 79 percent of the groundwater samples from New Jersey and Martha's Vineyard, Massachusetts, had pH values below 6.0. In contrast, only 19 percent of the samples collected in the Appalachian region in Round 3 had pH values below 6.0.

The 0.01 mg/L limit for aluminum in kidney dialysis water was often exceeded in raw waters. More than 40 percent of the raw surface waters from Rounds 1 and 2 had aluminum concentrations of 0.1 mg/L or higher, and about 15 percent of the raw groundwaters sampled in Rounds 1, 2, and 3 reached or exceeded this level. Only kidney dialysis patients need to be concerned about the health aspects of ingested aluminum at these levels.

Forty-three sets of three household samples were collected. Analysis of household water samples showed that copper equalled or exceeded the 1 mg/L SMCL in 42 percent of the water samples held overnight in household plumbing, in

Table 1. Cadmium, Lead, and Mercury in Waters Sampled

Type of Sample	Cadmium (0.010 mg/L MCL)		Lead (0.05 mg/L MCL)		Mercury	
	No. > MCL	No. Samples	No. > MCL	No. Samples	No. > MCL	No. Samples
	<i>Raw Surface Water:</i>					
Round 1	0	120	0	119	1	120
Round 2	0	42	0	42	1	42
Total	0	162	0	161	2	162
<i>Raw Groundwater:</i>						
Round 1	0	12	0	12	0	12
Round 2	0	83	1	83	0	83
Round 3	0	71	1	71	0	71
Total	0	166	2	166	0	166
<i>Treated Surface Water:</i>						
Round 1	0	101	1	101	0	101
Round 2	1	33	1	33	0	33
Total	1	134	2	134	0	134
<i>Treated Groundwater:</i>						
Round 1	0	10	0	10	0	10
Round 2	0	12	1	12	0	12
Total	0	22	1	22	0	22

21 percent of the water samples held overnight in service lines, and in only 5 percent (2 of 43) of the samples flowing directly to the tap from the distribution system. Likely sources of copper are copper service lines and household plumbing.

Lead equalled or exceeded the 0.05 mg/L MCL in 8 percent (7 of 86) of the household plumbing or service line samples but did not exceed the MCL in water samples flowing directly to the household tap. Sources of lead could include lead service lines, lead plumbing, and lead-tin solder used to join copper pipes and fittings.

Cadmium in the household water samples never exceeded the 0.010 mg/L MCL, and zinc never exceeded the 5 mg/L SMCL.

The water quality indices calculated for the waters sampled indicate that the raw waters in Rounds 1 and 2 tend to dissolve  $\text{CaCO}_3$ . The Langelier Index was less than -2 for 85 percent of Round 1 raw waters and less than -2 for more than 90 percent of Round 2 raw waters. Values of Ryznar's Stability Index exceeded 8 for 97 percent of Round 1 waters and 96 percent of Round 2 waters. These stability index values have been associated with water main corrosion and rusty water problems by Ryznar. More than 60 percent of the raw waters from Round 1 and more than 70 percent of the raw waters from Round 2 had Calcite Saturation Index values greater than 3, indicating susceptibility to change.

Alkalinity data for raw waters in Massachusetts were analyzed for trends over time. Data for four or five decades were available for most of the water sources in this analysis. Of the 34 sources, 20 had slopes statistically different from zero (0.05 level). Alkalinity in 18 of the 20 sources has declined over the time for which data are available, whereas alkalinity has increased in two water sources. Both in alkalinity and pH of Scituate Reservoir (in Rhode Island) have shown declining trends that are statistically significant at the 0.05 level.

## Conclusions

1. Raw water concentrations of cadmium, lead, and mercury very seldom exceeded the MCL's (1 in 484 samples for Cd, 5 in 483 samples for Pb, and 2 in 484 samples for Hg).
2. Raw water pH was frequently below pH 6.5, the lower limit of the pH range in the SMCL.

3. Stability Index values for many of the waters sampled indicate that the waters are corrosive to iron pipe.

4. Household waters were found to be corrosive. About 40 percent of the overnight samples from household piping met or exceeded the 1 mg/L SMCL for copper. Eight percent (7 of 86) of household and service line samples had lead concentrations at or above the 0.05 mg/L MCL, whereas none of the samples flowing directly from the distribution main to the tap exceeded this level.

5. Alkalinity data recorded in the past four to five decades showed that alkalinity had declined in 18 of 34 raw water sources in Massachusetts and increased in two sources. The slope of the least squares fit of alkalinity versus time was not statis-

tically different from zero (0.05 level) for the other 14 raw water sources.

6. No direct relationship was found between acid precipitation and the decline in alkalinity in the 18 raw water sources, nor was any relationship found between acid precipitation and the unstable and potentially corrosive nature of these sources. The potentially detrimental effects of acid precipitation should not be discounted, however, given the limited buffering capacity in these supplies, the historical downward trend in alkalinity, and the low pH of the rainfall in the study area. More study should be undertaken on this issue.

The full report was submitted in fulfillment of Cooperative Agreement CR-807808010 by the New England Water Works Association under the sponsorship of the U.S. Environmental Protection Agency.

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*The complete report, entitled "Acid Precipitation and Drinking Water Quality in the Eastern United States," (Order No. PB 84-157 932; Cost: \$ 17.50, subject to change) will be available only from:*

*National Technical Information Service  
5285 Port Royal Road  
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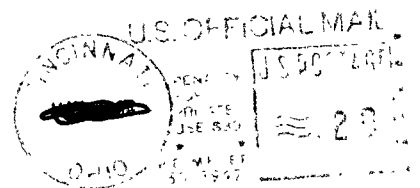
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