DEVELOPING REGULATORY PROGRAMS FOR THE CONTROL OF ACID PRECIPITATION

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ABSTRACT

The U.S. Clean Air Act provides mechanisms by which the public welfare may be protected from "any known or anticipated adverse effects associated with the presence of (an) air pollutant in the ambient air." The history of the U.S. Environment Protection Agency's (EPA) efforts to establish and defend a secondary ambient air quality standard for sulfur oxides is reviewed. The role of acid rain in producing "welfare effects" is described. Emphasis is given to the fact that a wide range of effects not simply limited to forest vegetation must be considered when designing pollution control programs.

The possible effects of ignoring acid rain in developing control strategies to meet health related standards for sulfur oxides, nitrogen oxides and particulates are mentioned. Researchers need to be aware of the kinds of information which are needed by regulatory agencies before a regulatory program can be designed for alleviating the threat. Concern and speculation are not adequate. Accurate dose-response information and cumulative damage estimates are needed to quantify the effects of acid rain. Of vital importance are: (1) discovery of pollutant concentrations, mechanisms, and atmospheric conditions which lead to harmful effects: and (2) identification of major sources of the pollutant. The effect such information could have on techniques for meeting ground-level air-quality standards such as tall stacks and Intermittant Control Systems (ICS) is discussed. The desirability of an integrated research effort in this area to answer these needs is stressed. EPA efforts in this regard are mentioned.

INTRODUCTION

Recent reviews of available data (1,2,3) indicate that precipitation in a large region of the United States is highly acidic when compared to the expected pH value of 5.7 for pure rainwater. Figure 1

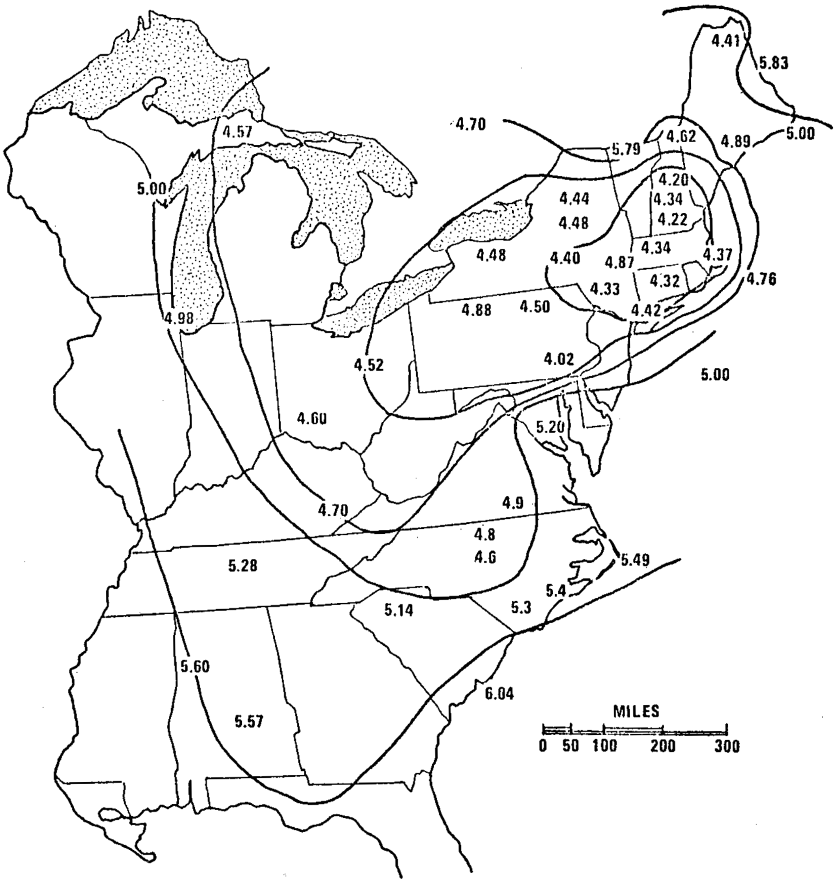

Figure 1. Rainfall acidity, 1965 - 1966 (pH units).[1]

shows that the average pH of precipitation in the northeastern U.S. was routinely less than 4.7 in the mid 1960's. More recent information indicates that in this area, pH's between 3.0 and 4.0 are observed during individual storms.(3,4) Analyses of historical trends suggest that the regional acid rain phenomenon began to develop in the early 1950's and has widened and intensified to some extent since that time. (1,3) The causes of this situation are not well understood, but it has been suggested that acid rain is related to regional emissions of acid forming air pollutants, chiefly sulfur oxides and nitrogen oxides.(3,5)

A growing body of evidence suggests that acid rain may be responsible for substantial adverse effects on the public welfare. Such effects may include acidification of lakes, rivers and groundwaters, with resultant damage to fish and other components of aquatic ecosystems;(6) acidification and demineralization of soils,(7) reduction of forest productivity,(8) damage to crops, and deterioration of man-made materials.(2) These effects may be subject to cumulative build-up as a result of years of exposure to acidic precipitation but some may also result from "peak" acidity episodes.

It is of great importance that the causes and consequences of acid precipitation become more fully understood in the near future so that corrective measures can be taken to minimize any deleterious effects. This paper will briefly outline the regulatory options available in the United States for implementing control programs designed to protect public welfare. It will also discuss some of the past experiences with such programs with regard to the importance of developing a sound data base to support regulatory strategies. In addition, emission projections are presented to indicate the trends in precipitation acidity over the next several years under current Federal and State control programs. Also, important areas for further research leading to the establishment of a regulatory program for acid rain are suggested.

THE CLEAN AIR ACT

The Clean Air Act as amended in 1970 and 1974 is the basic U.S. Federal Law for controlling the adverse effects of air pollution. Air-pollution control organizations must determine how much of the acid precipitation problem will or can be solved through current regulatory mechanisms provided under this Act. The first task of establishing any pollution-control program is the analysis of available scientific information. In this analysis, knowledge of a pollution threat is matched with regulatory options available for controlling the pollution problem. The entire problem/regulatory option-assessment is called "a prefered standards path analysis."

As provided by the Clean Air Act, air pollution can be controlled in several ways. The basic regulatory options available are: (1) National Ambient Air Quality Standards, (2) Performance Standards for New Sources, (3) National Emission Standards for Hazardous Pollutants, (4) National Emission Standards for Mobile Sources, (5) Regulation of Fuels and Fuel Additives, and (6) Abatement Conferences.

The National Ambient Air Quality Standards (NAAQS) (Section 108 of the Act) specify an ambient concentration of a pollutant over a prescribed time period which cannot be exceeded. There are two types of NAAQS: the primary standards which are designed to protect public health and the secondary standards which are designed to protect the public welfare. In general, a pollutant is considered a likely candidate for NAAQS if its presence in the air is the result of numerous and diverse mobile and stationary sources.

New Source Performance Standards (NSPS) (Section 111 of the Act) are emission limitations for new or modified sources which contribute significantly to air pollution which causes or contributes to the endangerment of public health or welfare. The NSPS for any specified pollutant must be based on the best degree of control, including the consideration of cost, and must be adequately demonstrated. Also, no new source, even if it meets NSPS, can be operated if it will cause a violation of a National Ambient Air Quality Standard.

National Emission Standards for Hazardous Pollutants (NESHAP) (Section 112 of the Act) are established for pollutants for which there is no NAAQS and which may cause an increase in mortality or serious irreversible, or incapacitating reversible illness in men. Pollutants for which these standards are established are a more serious threat to the public health than pollutants controlled by the NAAQS. To date, hazardous emission standards have been established for significant sources of atmospheric mercury, asbestos, and beryllium.

Standards are established for pollutants emitted from mobile sources (Section 202 of the Act) which harm public health or welfare. Mobile source emission reductions for CO, HC, and NO_x as mandated by the 1970 Clean Air Act require a 90 percent reduction from 1970 levels for each of the pollutants.

Section 211 of the Clean Air Act provides for the registration and control of any fuel or fuel additive. Under this section of the Act, manufacturers may be required to give the name of any additive, the concentration of the additive in the fuel, the purpose of the additive, and the chemical composition of the additive. Also, the law provides that the manufacturer conduct tests to determine the possible health effect of any additive or the emissions resulting from the use of the additive.

Interstate or international air-pollution problems are addressed under the Abatement Conference Section of the Clean Air Act (Section 115). As a result of conference recommendations addressing problems which span state or national boundaries, the law provides authority to seek court relief to ensure abatement.

POTENTIAL APPLICATION OF REGULATORY OPTIONS TO ACID RAIN

The characteristics of the potential acid-precipitation problem are somewhat unique. It is hypothesized that atmospheric emissions of precursors such as SO_2 and NO_2 are transformed into strong acids before or during transferal between air and rainfall. The precipitation then plays an important role in concentrating and delivering the pollutants in a form in which they can be more damaging than if they were present as gases dispersed throughout the mixing layer. The connection between emissions, atmospheric concentrations, and effects is thus mediated through precipitation removal processes. Nevertheless, a strategy for acid-precipitation control could be applied under existing clean air options. The most effective means for control would probably center around a set of strategies based on the attainment of National Ambient Air Quality Standards and New Source Performance Standards for acid precursor pollutants.

Previous experiences with the establishment of ambient air quality standards have pointed to a need to have a sound scientific basis. When the SO_x standards were first promulgated in 1971, the scientific basis for the annual 60 micrograms per cubic meter ($\mu g/m^3$) standard was successfully challenged by industry. In a defense of the need for the standard, it could not be shown that the annual 60 $\mu g/m^3$ level specified by the standard would prevent any specific environmental effect. As a result, the standard was revoked. The lesson which was learned pertaining to any future air quality standards related to acid rain, is that soundly quantified scientific evidence is clearly needed. In addition, the scientific community must be willing to stand behind standards, many times calling upon their scientific judgment, to render support. This is especially important when considering the many hard-to-quantify effects which are apparently caused by acidic precipitation.

Table 1 lists the National Ambient Air Quality Standards for acid

Table 1

U.S. AMBIENT AIR QUALITY STANDARDS

POLLUTANT	AVERAGING TIME	PRIMARY STANDARDS	SECONDARY STANDARDS
SULFUR OXIDES	ANNUAL (ARITHMETIC MEAN)	80 $\mu g/m^3$ (0.03 ppm)	—
	24 - HOUR	365 $\mu g/m^3$ (0.14 ppm)	—
	3 - HOUR	—	1300 $\mu g/m^3$ (0.5 ppm)
NO_2	ANNUAL (ARITHMETIC MEAN)	100 $\mu g/m^3$ (0.05 ppm)	(SAME AS PRIMARY)

precursor pollutants. All 55 States and territories are required to have plans which provide for the attainment and maintenance of these as well as the other National Ambient Air Quality Standards.

At the present time, only a three hour secondary standard for SO_2 exists for the prevention of damages in the same category as those caused by acidic precipitation. However, when compared to the many effects caused by acid precipitation, the basis for this current secondary standard is rather unimpressive. For example, the reason for the standard is prevention of leaf spotting on vegetation. Reasons for preventing acid precipitation could conceivably surpass this in many respects. Compared to the research effort and information being collected around the world on health effects, research to date concerning the adverse effects of acidic precipitation is extremely limited.

The control of acid precipitation through the attainment and maintenance of Air Quality Standards is possible only if the standards are met through emission reduction. One convenient way for meeting an air quality standard is obviously through the use of dilution techniques such as tall stacks and intermittent control systems. But if one accepts the notion that acid rain is a potentially serious regional and ecological problem that may be related to regional emissions of acid precursors, then total sulfur and nitrogen loading of the atmosphere must be controlled. Identifying the environmental damages resulting from acid rain provides yet another reason for limiting dilution strategies and encouraging the use of control devices and fuels which reduce the total sulfur and nitrogen loading of the atmosphere.

One viable means of countering the growth of gaseous acid precursors is through the establishment of additional New Source Performance Standards. Table 2 shows some typical acid presursor emitting

Table 2

SOME OF THE NEW SOURCE PERFORMANCE STANDARDS

BEST AVAILABLE CONTROL TECHNOLOGY

FOR

STEAM GENERATORS (SO_2, NO_2, TSP)

SULFURIC ACID PLANTS (SO_2)

NITRIC ACID PLANTS (NO_2)

PETROLEUM REFINERIES

sources for which NSPS are currently in effect. Standards for sources such as these not only provide for the attainment of the NAAQS, but in the long-run, as existing sources die out, could provide for a downward trend in regional pollutant emissions causing atmospheric acid formation.

TRENDS AND PROJECTIONS

Some authors (2,3) have expressed the concern that regional acid precipitation may markedly increase over the next several years due primarily to increased SO_x and NO_x emissions resulting from coal combustion. The region of greatest concern is the northeastern quadrant of the nation. This region is also of importance with respect to investigation of atmospheric suspended sulfates and their effect upon public health. Based on suspended sulfate measurements, a 24-state area (Figure 2) had significantly higher sulfate concentrations than the rest

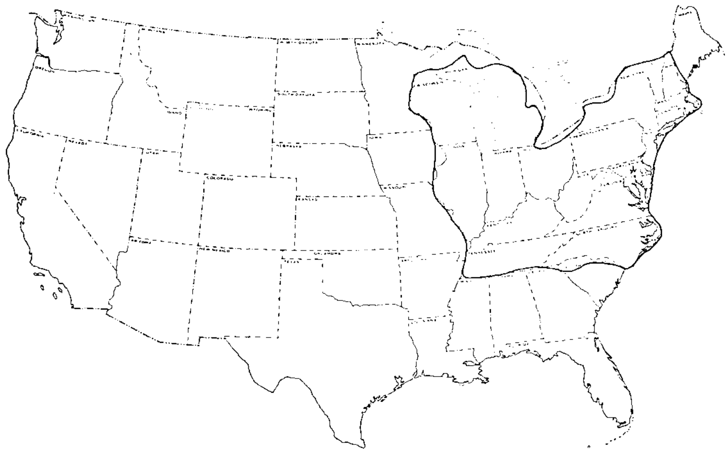

Figure 2. High sulfates 24 State Region

of the nation. Comparison of Figure 2 with Figure 1 indicates that this region is quite similar to that impacted by precipitation of pH5 or less. Some information on the likely trends for acid precipitation can be obtained from examination of emissions projections originally made to project trends in acid sulfate aerosol levels.(9) SO_2 emissions for this region from 1969 projected through 1980 are presented in Figure 3.

These projections assume that current State and Federal SO_2 emission limits are successfully implemented through the 24-State Region. Assuming that SO_2 is one of the more important agents in forming the regional acid precipitation, a dramatic increase in sulfuric acid related precipitation over the next few years is not anticipated.

It is interesting to note that in the time period 1969 to 1974 which the historical data covers, that SO_2 emissions remain essentially constant. This seems to be in agreement with the results of the Hubbard Brook Work (3,1) where the sulfate in precipitation remained about constant during the same time period.

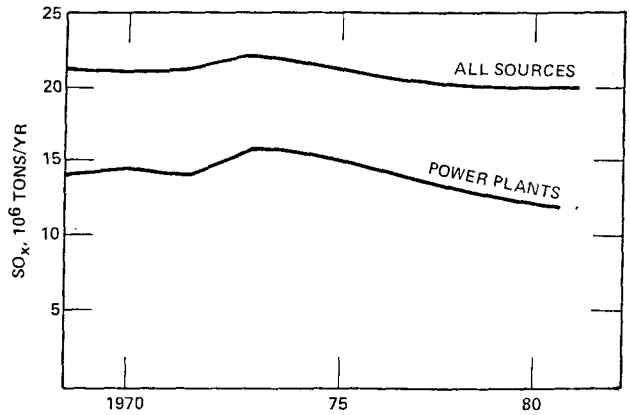

Figure 3. Projected SO_x Emissions, 24 State Region.

The historical NO_x emissions data base is less reliable than that for SO_2. However, based on projections by the National Academy of Sciences (10) and 1972 data compiled by the National Emissions Data System of EPA, NO_x emissions in this 24-State Region might increase from 15 × 10^6 tons in 1972 to about 18 × 10^6 in 1980.

Although SO_2 emissions will be limited to the extent necessary to attain and maintain the National Ambient Air Quality Standards, they may not be doing much to alleviate the cumulative effects of acid precipitation. A feeling exists that acid rain causes an adverse buildup in the environment. Feelings or speculations are not enough, however. More hard, conclusive evidence of the acid rain's relation to air pollution are needed before regulatory programs can be established.

RESEARCH NEEDS

The most basic need for establishing a regulatory program for acid precipitation is to be able to intelligently relate the sources which can be regulated to damages caused by acid rain.

Some of the more specific elements of these basic research needs are posed in the following questions:

What pollutants and levels of those pollutants significantly contribute acid rain? (SO_2, NO_2, HCl, etc.?)

What is the relation between pollution concentration and environmental damage? Is the old approach to measuring ground-level concentrations satisfactory?

What is the relationship between pollutant emissions and environmental damages? (Transport and Transformation Models)

Where are the regions most affected?

What kinds of sources predominate in those regions?

What is the natural composition of and potential for environmental damage in those regions?

What emission controls are available?

What is the most efficient control strategy?

What are the benefits of preventing acid precipitation?

Are the proposed control strategies enforceable?

Are goals for controlling acid rain realistic?

In summary, acid rain may be a serious environmental problem which will require regulation within the next few years. Past experience has taught air quality regulators that a sound scientific base is a necessary ingredient for developing effective regulatory control programs. The information base must be broad in nature and cross the boundaries of different disciplines. The acid-rain problem must be understood all the way from the sources which emit acid pollutants through the varying atmospheric transformations and on into an affected environment. Concerned citizens, scientists, government regulatory agencies, and industry must cooperate to the address the acid-rain problem.

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