

EXECUTIVE SUMMARY

TO

VISIBILITY REDUCTION AS RELATED TO AEROSOL CONSTITUENTS

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Introduction

Visibility reduction results from a combination of light scattering and absorption by particles and gases in the atmosphere. Numerous studies have examined the relation between pollutant concentration and visibility reduction. Until recently, however, only light scattering was considered. Furthermore, all previous visibility studies have been subject to sampling errors for one or more aerosol species important in light scattering, viz., sulfates and nitrates.

Accurate assessment of the significance of different aerosol constituents to visibility impairment can be useful to the ARB in designing cost-effective control strategies for visibility improvement. Furthermore, an accurate data base can reduce the likelihood of legal challenge to control measures adopted by the Board.

Objectives

A laboratory and field study was performed to assess the contributions to visibility reduction of both light scattering and absorption by air pollutant particles and gases. Gaseous precursors to important visibility-reducing aerosol species were also measured. Emphasis was placed on minimizing sampling artifacts for pollutant particles. Optical techniques to measure the particle absorption coefficient and elemental carbon were evaluated.

Procedures

The aerosol species measured were fine and coarse particulate mass, sulfate, nitrate, elemental carbon, plus total particulate organic carbon and ammonium ion. The gases measured were nitric acid, NH_3 , SO_2 , NO_2 and O_3 . Summertime sampling was done for 109, 4-hour periods, generally between 0800 and 2400 hours, at San Jose, Riverside and downtown Los Angeles during July and August 1982.

Results

The mean visual ranges encountered were 40 Km at San Jose, 15 Km at Riverside and 13 Km at downtown Los Angeles. The mean four hour average ozone concentrations ranged from 0.02 to 0.07 ppm. Thus, relatively light photochemical smog was experienced.

Light scattering by sulfate, nitrate and elemental carbon particles was the largest contributor to the total light extinction at all sites, representing more than half of the extinction coefficient (b'_{ext}). Light absorption by particles, due almost exclusively to elemental carbon, was relatively unimportant in the South Coast Air Basin where high concentrations of sulfate and nitrate were present. At San Jose, however, absorption averaged nearly 22% of b'_{ext} . Conversely the apparent contribution to light scattering by water was relatively high at Riverside and Los Angeles but small at San Jose. Light absorption by gases, due only to nitrogen dioxide, was small at all sites. The scattering efficiency per unit mass of fine particulate nitrate appeared to be greater than that for fine sulfate, in

contrast to most previous studies. The scattering efficiency for fine elemental carbon was similar to that for fine sulfate. Coarse nitrate, coarse elemental carbon, and organic carbon, did not exhibit a significant scattering efficiency.

Considering both light scattering and light absorption, and apportioning the light scattering by water between the hygroscopic species sulfate and nitrate, based on multiple regression analysis, fine sulfate, fine nitrate, fine elemental carbon and NO_2 contributed on average, 30%, 36%, 20%, and 8%, respectively, of the total extinction (excluding Rayleigh scattering).

Principal Conclusions

1. The light scattering efficiency of fine particle nitrate appears to exceed that of sulfate in contrast to the results of most previous studies. Since both positive and negative sampling artifacts were minimized, we believe these results to be correct.
2. Light absorption by elemental carbon plays a significant role in visibility reduction in urban areas in California, and is especially significant when concentrations of fine sulfate and nitrate are relatively low.
3. Particle-phase water contributed substantially to visibility reduction at sites with relatively high levels of sulfate and nitrate, species which can absorb moisture.

Implications for Regulatory Programs

1. Control of oxides of nitrogen emissions can be even more significant than that for sulfur oxides in visibility improvement.
2. Control of elemental carbon emission sources (e.g. diesel vehicles) is a significant component of a strategy for visibility improvement.