

U.S. status of particulates - monitoring, modeling, background, trends, and standards.

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1. INTRODUCTION

Particulate matter (PM) has been measured in the United States as Total Suspended Particulates (TSP) and as particles of diameter 10 microns or less (PM_{10}). The first national ambient air quality standards (NAAQS) for PM were established in 1971 and were based on health data and air quality data assembled by the Department of Health Education and Welfare in 1969 [1]. The original standards were based on TSP as measured by the high volume sampler (or hi-vol) which had a sampling efficiency cut-point of 25 to 45 μm . The standards were set at that time to 1 exceedence of $260\mu g/m^3$ and an annual average limit of $75\mu g/m^3$. However, a review of the PM NAAQS, initiated in 1979 and completed in 1987 changed the basic indicator of particulate matter in the U.S. to PM_{10} and based the new standards on this indicator. The samplers for this indicator were hi-vols with a sampling efficiency cut-point set at $10\mu m$. The form and the level of the standards were changed at that time to 1 expected exceedence of $150\mu g/m^3$ for daily values and an expected annual average limit of $50\mu g/m^3$. In the ensuing years, the TSP monitoring network grew smaller while the PM_{10} network grew larger. At present, a NAAQS review is underway that will most likely add a new indicator, $PM_{2.5}$ (particles of diameter 2.5 microns or less), to the list of PM standards.

2. MONITORING

The monitoring method for PM in the U.S. is basically gravimetric, as opposed to nephelometer or beta gauge instruments. The reason for this is the ability to analyze a subset of filters for speciated compounds comprising the particulate mix. Such analyses are essential for control strategies and provide a better understanding of the dynamics of a regional or local particulate situation. Unfortunately, gravimetric methods incur high costs per sample and are manual methods. This has resulted in less than everyday sampling for the majority of the U.S. particulate networks (usually 1 in 6 day sampling).

The national U.S. network is composed of monitors that meet certain siting and method requirements and have been classified as part of the state and local air monitoring system

(SLAMS). A subset of these monitors meet more specific siting, purpose, and reporting requirements and are classified as part of the national air monitoring system (NAMS). Other monitors may meet one or more of these requirements and are classified as “special purpose” and “other” monitors. In 1981 the U.S. had a TSP hi-vol network of about 4000 sites. By 1995 the U.S. had a national network of 1737 PM₁₀ monitors while the TSP monitors had shrunk in number to about 600 monitors. These trends are shown in Figure 1. The data from these networks are used to develop the trends analyses presented later in this paper. Due to the proposed new standards, a PM_{2.5} network will be deployed nationwide, while some reduction will occur in the number of PM₁₀ monitors. However, this reduction will not be as dramatic as the reduction in TSP monitors since the PM₁₀ standards will also be retained [5].

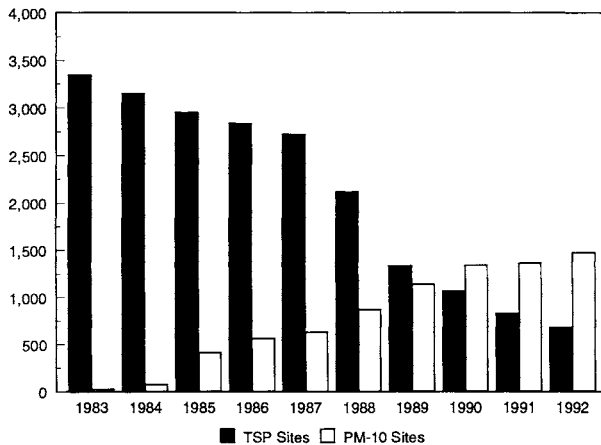


Figure 1. Trends in TSP and PM₁₀ Sites in the U.S. from 1983 to 1992.

3. BACKGROUND LEVELS

Natural sources contribute to all size fractions of particulate matter. Since the determination of background usually affects what controls need to be made and where standard levels should be set, defining background concentrations is usually a non-trivial exercise that is complicated by different agendas brought to the scientific table. Add to that the knowledge that background levels can vary widely depending on what area is being discussed and on how background levels are defined. The Environmental Protection Agency (EPA) considers background to be those levels that would result in the absence of anthropogenic emissions of particulates and their precursors. A more complete treatment of background levels can be found in NAPAP, 1991 [2] and Trijonis, 1982 [3]. A less rigorous treatment can be found in Malm *et al.*, 1994 [4].

The actual background levels are shown in Table 1. The lower end of the range is from NAPAP (1991) and Trijonis (1982) while the upper end is from Malm *et al.* (1994). In general, the more industrialized and populated East has higher background levels than the West.

Table 1.
Background Levels of PM_{10} and $PM_{2.5}$

	Western U.S. ($\mu\text{g}/\text{m}^3$)	Eastern U.S. ($\mu\text{g}/\text{m}^3$)
PM_{10} - annual average	4-8	5-11
$PM_{2.5}$ - annual average	1-4	2-5

4. MODELING ACTIVITIES

Particulate modeling has, in general, been confined to local efforts using gaussian plume model techniques. Urban scale modeling has been performed with the urban airshed model (UAM). The Regulatory Modeling System for Aerosol and Deposition (REMSAD) is more sophisticated and accounts for secondary particle formation. More recent activities revolve around the regional acid deposition model (RADM) and the regional particulate model (RPM). These models are even more sophisticated and incorporate complex chemistry to model secondary particulates. However, the most sophisticated particulate model is to be part of a larger modeling system, Models 3, which will model ozone, carbon monoxide, and particulates on a regional scale. A beta test version is hoped to be available by the Summer of 1997 while the production version may be available in the Summer of 1998 [6].

5. TRENDS

Particulate trends are characterized by data from the national network meeting longevity and data capture requirements. Specifically, for a 10-year period, a site must have enough data to complete 8 valid years before the data from this site is included in the trends analysis. With those requirements and remembering that the U.S. switched to PM_{10} in 1987, the latest analyses

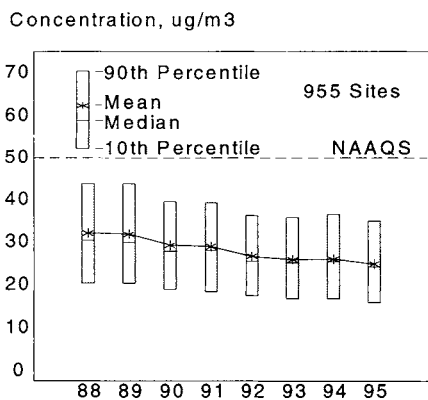


Figure 2. Trends in PM_{10} annual Mean

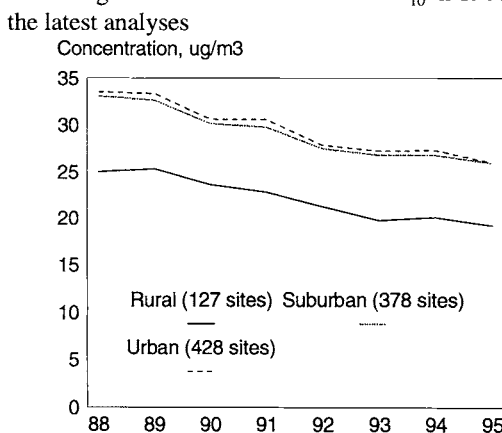


Figure 3. PM_{10} trends by Location.

comprise the 8 year period for 1988 to 1995 during which a monitor had to have 7 valid years of data. In the U.S. trends are reported as national composite statistics from sites meeting the criteria. The specific statistic used is related to the NAAQS for the pollutant being reported. Therefore, for PM_{10} , the composite statistic is based upon the annual mean. Examining these trends, PM_{10} decreased 22% during this period and 4% for the short term period 1994 to 1995. As can be seen in Figure 3, composite averages for urban and suburban sites are almost identical, while the composite average for rural sites is similar but substantially lower.

Looking at trends in traditionally estimated or inventoried emissions (Figure 4), the long-term decrease in emissions was 17% for the period 1988 to 1995 and 6% for the short-term period 1994-1995. These emissions are from fuel combustion, industrial processes, and transportation. For the first time in recent years, emissions from industrial processes were estimated to be higher than fuel combustion emissions. Industrial process emissions increased 1% from 1994 to 1995 while fuel combustion emissions decreased 12% over the same time period. However, the traditionally estimated emissions make up only 6% of total PM_{10} emissions nationwide. The other categories are natural sources such as wind erosion, miscellaneous sources such as agriculture and forestry, fires (both controlled and wildfires), and fugitive dust from paved and unpaved roads. Fugitive dust emissions are the largest component to total PM_{10} emissions, making up 68%. It should be noted that the sharp decrease seen between 1989 and 1990 is an artifact of changes made in data gathering and calculations of emissions for particulates in 1990.

In 1995 there were 24 million people living in 22 counties that had concentrations above either the daily or the annual PM_{10} NAAQS levels [2].

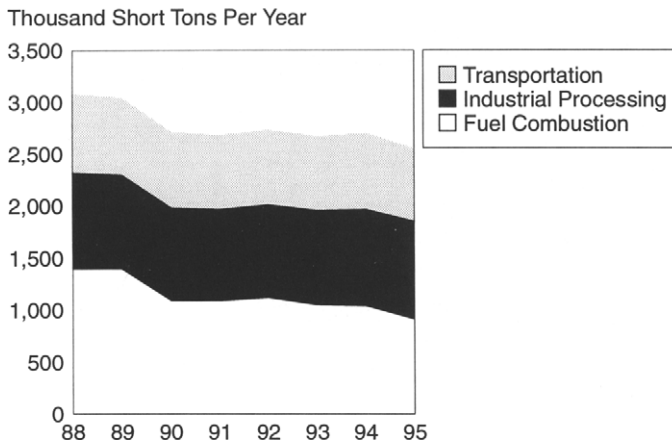


Figure 4. Trends in PM_{10} emissions for 1988 to 1995.

6. NEW STANDARDS

Changes to the particulate matter NAAQS have been proposed in the U.S. Recent health studies have indicated that significant portions of the populations are inadequately protected by

the present standards. Several epidemiology studies have suggested that fine particulates might be causing severe health effects such as premature death and morbidity (for example [7, 8, 9]). In response to this new information, the EPA has proposed both daily and annual ambient air quality standards for $PM_{2.5}$. PM_{10} standards will also be retained. Due to variable sampling schedules and uncertain data capture for PM monitors, the daily standard for both PM_{10} and $PM_{2.5}$ has been proposed as a 3-year average of the 98th percentile of yearly data at a site. This approach moves away from the so-called exceedence form used for the present PM_{10} daily standard and towards a concentration based standard recommended by many advisors to the agency. The annual standard remains the same for PM_{10} , the 3-year annual average concentration must be less than $50\mu\text{g}/\text{m}^3$. However, for $PM_{2.5}$ the annual average of several monitors will be allowed to produce a spatially averaged annual mean. This is a significant new step in setting air pollution standards for the agency and has generated much discussion.

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