United States
Environmental Protection
Agency

Environmental Monitoring
Systems Laboratory
Research Triangle Park NC 27711

Research and Development

EPA-600/S4-84-088 Mar. 1985

EPA

Project Summary

Inhalable Particulate Network Report: Operation and Data Summary (Mass Concentrations Only)

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This report is intended to serve as an operations overview and data summary covering the operation of the 157 Inhalable Particulate (IP) Network sites within the United States. Volume I discusses the scope of the Network and instrumentation utilized in the Network. Data (mass only) are traced from measurement through processing and storage to routine reporting. Quality assurance practices are also given. Data summaries are provided. Volume II is a list of individual data upon which Volume I is based.

Analyses, conclusions, and examples, either listed or indicated by reference, should provide the reader with both suggested uses and possible limitations of the data. Chemical analysis of the collected particulate (sulfate, nitrate, and selected metals) is part of IP Network objectives but those data will be the subject of a separate report.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Research Triangle Park, NC, 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

The 1977 Clean Air Act Amendment requires a reappraisal of the National Ambient Air Quality Standard for particulate matter. In order to meet this requirement, information regarding both Total Suspended Particulate (TSP) and smaller inhalable particles was required.

EPA's Environmental Monitoring Systems Laboratory (EMSL), Research Triangle Park, NC, in conjunction with EPA's Office of Air Quality Planning and Standards was given the responsibility of providing ambient air data for the small particle size range. The exact value for the upper limit, however, was and still remains, controversial. Therefore, data from both the original 0-15 μm samplers and the subsequent 0-10 μm samplers are included. In 1977-78 when the Inhalable Particulate (IP) Network was being planned, the major monitoring emphasis was on collection devices which could provide measurements of ambient air concentrations attributed to 15 μm (and smaller) particles and 2.5 μm (and smaller) particles. For these reasons instruments using inlets providing a single sample (15 μm and smaller) and dual samples (2.5 to 15 μm and below 2.5 μm) were evaluated and utilized. Both are referred to as PM_{15} to designate the upper limit of 15 μm.

Procedure

In 1978, the data from the Inhalable Particulate Network were anticipated to be used primarily to assist in a revision of the existing Total Suspended Particulate Standard. The revised standard was to be based on the specific particle size range of 15 μm mean aerodynamic diameter and below, and to a lesser degree to provide information on the possible sources of the particles for subsequent control strategy implementation. To accomplish this, establishment of a nationwide network of 200 air monitoring

sites over a three-year period was planned. However, due to resource constraints, only 157 sites were placed on line.

The following specific Network objectives and design criteria were provided by the Office of Air Quality Planning and Standards (OAQPS): (a) conduct a pilot program to demonstrate that the monitoring technology was adequate to proceed with the study (technology to make routine size-specific aerosol measurements had only recently become commercially available), (b) provide monitoring support to on-going epidemiology studies wherever possible, (c) provide background data for non-urban and rural sites, (d) monitor fugitive dust locations, (e) select urban sites with priorities primarily for population density and non-attainment of the current TSP standard, (f) at all sites, measure the mass concentration of TSP and IP, (g) at selected sites, measure the fine and coarse components of IP (i.e., PM_{15}), and (h) provide for a limited component analysis scheme beyond mass concentration to further characterize the data base. Later, a final objective was added: (i) incorporate PM_{10} technology into the network for data collection in the 0-10 μm size range.

OAQPS specified the candidate cities. With OAQPS approval, EMSL and/or an EMSL contractor made the specific site selection within the city, based on desired site classification (Commercial, Residential, Industrial, Rural, etc.) and specific site availability.

All of the objectives and constraints were combined into a protocol of network operations, which was prepared prior to network implementation. This protocol included the various aspects of network design and setup, sample collection, analyses, quality assurance, maintenance, and data processing and analyses. All operations except the actual collection of samples would be provided by EPA. Manpower was to be provided by State and local agency personnel to implement the operation of the sampling equipment. Because of the limited manpower available within EPA, contractor support was also planned. A Quality Assurance program was planned and budgeted at 5-10% of resources.

Although each sampling site location was physically evaluated against the siting criteria given in the *Inhalable Particulate Network Operations and Quality Assurance Manual*, March, 1983, administratively the selection process was quite variable. Land owner permission, local agency approval, Regional Office concurrence, OAQPS recommendations/concurrence all had to occur in order for a specific site to begin and continue sample/data collection. Further, since more than 1,000 people were eventually involved directly in the data gathering activities, their performance, interest, and assistance directly affected the amount and quality of data collected. In spite of the diverse demands on time, personnel and resources, EMSL received excellent cooperation from local, State, and Regional personnel. This cooperation resulted in data collection from 525 sampler-years from 157 sites.

All sites provide routine TSP data from a Hi-Volume sampler and PM_{15} data from either a Size Selective Sampler (SSS) or Dichotomous Sampler. In addition to routine sampling requirements, EMSL utilized selected sites for intercomparison of instruments. At various times a given site became one or more of the following:

1. *Comparison Site:* In addition to the instrument complement of a PM_{15} and a TSP Hi-Vol for routine sampling, some of the initial sites were provided with additional PM_{15} instruments. These special sites provided data for comparison of SSS-to-Dichotomous, etc. Eventually 128 sites had both SSS and Dichotomous 15 instruments.

2. *Collocated Site:* A site containing duplicate instruments of the same type and usually by the same manufacturer. Duplicates include Dichotomous PM_{15} to Dichotomous PM_{15}, TSP-to-TSP, SSS_{15}-to-SSS_{15}, Dichotomous PM_{10} to Dichotomous PM_{10}. Twelve sites were utilized for collocated data collection

3. *Key Site:* An existing PM_{15} site which was augmented with a PM_{10} monitor. The objective for a key site is to provide data for both PM_{15} and PM_{10}. Nine sites were designated as key sites.

In early 1978, when the IP Network was being planned, a recently developed dichotomous sampler was available and was incorporated into the network. This sampler provided two particle size fractions. The larger size fraction (Coarse) included particles from 2.5 to 15 μm mean aerodynamic diameter. The smaller size fraction (Fine) included particles below 2.5 μm. When added together, the Fine and Coarse fractions give a "Total" inhalable concentration in the 0-15 μm range (PM_{15}). While the small fraction, "Fine," is not a requirement for defining an Inhalable Particulate Standard per se, it is useful in determining the origin of particulates.

The dichotomous sampler was therefore selected as the initial PM_{15} sampler because of availability and dual size range fractions. It was (and is) suitable for providing IP concentrations and, when paired with the standard Hi-Vol, IP/TSP relationships can be developed. The dichotomous sampler is more complex than the Hi-Vol and the two sample fractions (Coarse and Fine) require twice the sample handling, weighing, calculation, etc., as the Hi-Vol. Alternate samplers were therefore investigated. One PM_{15} sampler, The Size-Selective Sampler (SSS), was developed as a modification to a standard Hi-Vol and tested at 50 of the first field sites. This modified Hi-Vol sampler is identical to the TSP Hi-Vol except that the gable roof is replaced with a special mono-cut sampler offering ease of operation, single sample, large sample size, and associated cost savings. For TSP, the High-Volume sampler was used. Later a dichotomous sampler modified to cut at 10 μm was added.

Results and Discussion

The IP data base includes 12, 385 TSP Hi-Vol; 7,363 Size-Selective Inlet (SSS) Hi-Vol; and 11,056 Dichotomous Sampler 24-hour measurements, collected on an every-sixth-day schedule. Table 1 is a list of site locations. Volume I of the report is a summary of mass data collected. Volume II is a listing of individual 24-hour mass concentrations. Chemical analysis is not a subject of this report. Because of an initial emphasis on sites in the Philadelphia area to support other projects, a large percentage of the total data collection is from this area. Because of staggered sampler set up schedules and/or sampler downtime, TSP, SSS, and Dichotomous samplers were not always operated simultaneously. Therefore, care must be taken when comparing means of different sampler types. The number of samples, means, standard deviation, minimum, maximum, start date, and stop dates, are given in the main report.

Precision estimates were made by comparing duplicate, collocated like instruments. Like instruments are defined as similar instruments, or dissimilar instruments designed to do the same thing. Instruments were collocated

Table 1. Inhalable Particulate Network Site Locations

Region	State	Number of Sites	Location
4	Alabama	7	S. Birmingham, N. Birmingham, Inglenook, Huffman, Mobile, Mtn. Brook, Tarrant
10	Alaska	1	Anchorage
9	Arizona	3	Carefree, Phoenix, N. Phoenix
6	Arkansas	1	Little Rock
9	California	15	Azusa, Bakersfield, Chico, San Diego, Fresno, Five Points, Livermore (2), Lompoc, W. Los Angeles, Pasadena, Richmond, Rubidoux, San Francisco, San Jose
8	Colorado	5	Denver (3), Pueblo, Ft. Collins
1	Connecticut	2	Hartford, Morris Dam
3	Delaware	2	Dover, Wilmington
3	D.C.	2	Washington (2)
4	Florida	1	Tampa
4	Georgia	3	Atlanta (2), Savannah
9	Hawaii	1	Pearl City
10	Idaho	1	Boise
5	Illinois	4	Chicago (4)
5	Indiana	3	Gary, Indianapolis, Jeffersonville
7	Iowa	2	Marshalltown (2)
7	Kansas	3	Kansas City, Topeka, Wichita
4	Kentucky	2	Ashland, Louisville
1	Maine	1	Acadia
3	Maryland	5	Baltimore (3), Rockville (2)
1	Massachusetts	4	Boston (2), Springfield, Worcester
5	Michigan	7	Detroit (2), Duluth, International Falls, Minneapolis (2), St, Paul
4	Mississippi	1	Jackson
7	Missouri	3	St. Louis, Kansas City, E. St. Louis
8	Montana	2	Butte, Missoula
7	Nebraska	1	Omaha
9	Nevada	2	Reno, Winnemucca
2	New Jersey	3	Camden, Livingston, Jersey City
6	New Mexico	2	Albuquerque, Bayard
2	New York	7	Buffalo (2), Angola, Buffalo, NYC (3)
4	North Carolina	4	Charlotte, Durham, Res. Tri. Park (2)
5	Ohio	12	Akron, Cincinnati, Cleveland (3), Columbus, Dayton, Ironton, Medina, Middletown, Steubenville, Youngstown
6	Oklahoma	1	Oklahoma City
10	Oregon	3	Sauvie Island, Eugene, Portland
3	Pennsylvania	15	Bethlehem, Philadelphia (9), Pittsburgh (5)
1	Rhode Island	1	Providence
4	South Carolina	1	Charleston
4	Tennessee	2	Chattanooga, Nashville
6	Texas	6	Dallas, El Paso (2), Houston (3)
8	Utah	2	Magna, Salt Lake City
3	Virginia	6	Arlington, Hampton, Hopewell, Norfolk, Fairfax, Richmond
10	Washington	3	Seattle (2), Spokane
3	West Virginia	3	Charleston, Weirton, Wheeling
5	Wisconsin	2	Beloit, Green Bay
	Total	157	

at selected sites and duplicate samples were taken.

In the report, both bias and precision are addressed using formulas for summarizing paired data. The formulas are the "percent difference" ratio type commonly applied to collocated air pollution data.

When one compares actual measurements to a reference value or standard, the signed value of the percent difference is normally represented by:

$$\text{Percent Difference} = \frac{\text{Measurement-Reference}}{\text{Reference}} \times 100 \quad (1)$$

When comparing two field instruments, however, neither instrument is, in fact, a standard. A close approximation to equation (1) is:

$$\text{Percent Difference} = \frac{\text{Measurement 1 - Measurement 2}}{\text{Average of the 2 measurements}} \times 100 \quad (2)$$

If y_1 = measurement 1, and y_2 = measurement 2, equation 2 may be rewritten as:

$$\text{Percent Difference} = \frac{y_1 - y_2}{\frac{y_1 + y_2}{2}} \times 100 \quad (3)$$

The results of solving this equation for each pair of collocated sample measurements is the signed percent difference, R ($CV/\sqrt{2}$). For analysis each resultant (the signed percent difference R) was treated as a statistical sample. The hypothesis tested is that the average difference (i.e., the relative bias) is zero over each data set.

Data processing consists of:

1. Calculating the signed difference expressed as a percent (R explained previously) for each data-pair collected at each site (i.e., Coarse Fraction Dichot Mass collected in Birmingham, Alabama).
2. Calculating % Standard Deviation for each measurement pair.
3. Applying the Dixon Ratio to R for each data set to test for outliers.
4. Removing outliers.
5. Calculating the coefficient of variation where CV (%) = Standard Deviation of R divided by $\sqrt{2}$.
6. Testing the Null Hypothesis that R=O using the t-Test at $\alpha = .05$.
7. Testing the homogeneity of variances by applying Bartlett's test to variance of each mass measurement pair for each pollutant and measurement method. The test showed that a pooled estimate of variance was generally not possible although there were exceptions. It appears that for all the Hi-Vol data (TSP and 15 μm SSI) as well as dichotomous data the variances are nonhomogeneous.

Conclusions

Data from the EMSL, RTP Inhalable Particulate Network are described in the

report. Individual values for TSP Hi-Vol; PM_{15} Dichotomous Coarse, Fine, and Total; and PM_{15} SSS mass are presented. Ratios of Dichotomous Total-to-TSP Hi-Vol, and SSS-to-TSP Hi-Vol are summarized for PM_{15} mass. Similar data are presented for PM_{10} sampling but on a smaller number of samples. (More PM_{10} samples will become available as PM_{10} sampling continues throughout 1984).

Quality Control and Quality Assurance procedures and results are presented in the report and used to estimate sampling accuracy by examining sample flow rate, weighing accuracy, etc. Overall sampling accuracy is difficult to determine directly because the measurement requires the production of accurately known concentrations of particulate matter of a wide variety of sizes.

Data precision is discussed using paired data obtained from collocated instrument sampling. The signed percent difference of the two measurements (expressed as R) was obtained by dividing the difference between the data pair by the average of the two measurements and multiplying by 100. Student's t statistic was used to test the Null Hypothesis that R = O (i.e., that the relative bias is zero over each data set).

The value of t was statistically significant at the 5% level for one or more sites within each sampling class (Hi-Vol, SSS, $Dichot_{15}$) meaning that the differences between paired instruments is probably real. Conversely, at least one site within each class was not significant at the 5% level. Overall there is substantial variability but little bias across the entire collocated data set.

The general contention that suspended particulates are a complex mixture of large and small particles, both naturally occurring and man made, is supported by the absence of a simple, consistent ratio of IP to TSP. If the IP were a simple fraction of TSP, a consistent ratio would be expected and estimates of IP from past TSP would have been possible. That this is not the case and that IP is a complex fraction of TSP is supported by the data presented in the report.

The authors do not infer that for a specific site, a consistent ratio of IP-to-TSP is impossible. If a given site is influenced by particulates originating from a specific source, then the inhalable fraction may possibly be a consistent subset of TSP.

Certainly, at any given site, a ratio of IP-to-TSP is mathematically possible, but the actual value is dependent upon which (if any) outliers are identified as flawed and not used in the computations. Further experience with the operation of these samplers and with the interpretation of the resulting data will be needed to resolve the questions raised and to expand upon the conclusions that can be drawn.

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The complete report consists of two volumes:

"Inhalable Particulate Network Report: Operation and Data Summary (Mass Concentrations Only)—Vol. I., April 1979 - December 1982," (Order No. PB 85-148 682/AS; Cost: $19.00, subject to change).

"Inhalable Particulate Network Report: Data Listing (Mass Concentrations Only)—Vol. II., April 1979 - December 1982," (Order No. PB 85-148 690/AS; Cost: $34.00, subject to change).

The above reports will be available only from:

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☆ U.S. GOVERNMENT PRINTING OFFICE: 1985—559-016/27005

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