EPA's Role in Ambient Air Quality Monitoring

Methods used for ascertaining conformity to establish standards are described.

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The objectives of air pollution monitoring range from exploratory measurements for identifying essential parameters to the routine monitoring of those parameters chosen as indicative of the continued vitality of the biosphere. The Clean Air Act of 1970 (*1*) gives the U.S. Environmental Protection Agency (EPA) the responsibility and authority to take numerous actions to reduce and control air pollution. Specific provisions of the act require that National Ambient Air Quality Standards (NAAQS) be established by EPA and implemented by the states through EPA-approved State Implementation Plans (SIP). This article describes the ambient air monitoring required of the states, EPA's role in assuring that valid, comparable data are obtained and the use of the data.

National standards were established by EPA for those air pollutants that are harmful to the public health (those having effects on mortality and morbidity) and welfare (those having effects on vegetation, materials, visibility, and the like). In April 1971, five pollutants were identified as requiring standards: total suspended particulates (TSP), sulfur dioxide (SO_2), carbon monoxide (CO), photochemical oxidants (O_x), and nitrogen dioxide (NO_2) (*2*). Primary standards reflect the health-effect value, and secondary standards reflect the welfare-effect value (Table 1). For some pollutants, both short-term and long-term standards have been adopted. Long-term standards are annual mean concentrations that are not to be exceeded; whereas the short-term standards may be set at 1, 3, 8, or 24 hours, depending on the pollutant, and cannot be exceeded more than once per year.

In January 1972, each state government submitted an implementation plan describing the emissions reduction steps that would be made to meet, maintain, and enforce the NAAQS within its jurisdiction. Each state plan provided for the attainment of primary standards within 3 years of EPA's approval of the state plan; "reasonable time" was allowed for the attainment of secondary standards. Now, EPA proposes to amend the Clean Air Act to extend the deadlines for achieving NAAQS and thus allow the states greater flexibility in their implemention of control strategies.

The states were required by the SIP to establish air quality surveillance networks to monitor progress in attaining and maintaining the NAAQS. Data from these networks are used at local and state levels for determining whether standards are achieved. If air quality problems are identified, data from the networks form the basis for changes to the control strategy section of the applicable SIP. The states are asked to submit the ambient data on a routine basis to EPA. These data are then edited and stored in EPA's data bank, called National Aerometric Data Bank or NADB (*3*) and are made available to the contributing state agencies, scientific organizations, and the public. Various statistical summaries and analyses are performed and reported by EPA on a national scale (*4, 5*). The data are ultimately used in establishing control policies, priorities, and strategies.

Reference Methods

To increase the comparability of air quality data measured by the various state and local agencies, to assure that good, valid measurements are obtained, and to standardize measurement methodologies so that all agencies use the best available procedure considering cost and ease of operation, EPA has specified that certain measurement techniques (reference methods) be used by the states in their air quality monitoring networks for NAAQS pollutants. Thus, a reference method is a field-tested and -proven technique or instrument that is reasonable in cost and is relatively easy to operate and maintain. Measurement instruments that might be extremely precise and accurate, yet are costly, difficult to operate, or not field-tested would not be considered for designation as a reference measurement principle. Such instruments are, however, used in research projects.

Equivalent Methods

States are allowed to use other measurement techniques in their networks if equivalency to the reference method can be demonstrated. Equivalent methods have been generally defined as methods that can be shown to meet certain performance specifications and give measurements having a consistent relationship to a reference method.

The concepts of reference method and equivalency are not new within EPA but they have undergone considerable change of meaning over the last several years. These new concepts have been elaborated and detailed in depth in a recent issue of the *Federal Register* (*6*), which contains procedures for determination of ambient air monitoring reference and equivalent methods.

For example, an important new concept for continuous or automated analyzers is that of a measurement principle and calibration procedure. The EPA has not specified a reference method for continuous analyzers for certain pollutants as in the past, but rather a measurement principle and calibration procedure. Any automated analyzer using the specified measurement principle and associated calibration procedure and meeting the performance specifications can be designated as a reference method. For instance, in the past the nondispersive infrared (NDIR) technique was called the reference method for CO. This is no longer the case. The NDIR is the measurement principle for CO and any analyzer using the NDIR principle and specified calibration procedure and meeting the appropriate performance tests is designated as a reference method. Thus,

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there could be as many reference methods for CO as there are manufacturers or models of CO analyzers employing the NDIR measurement principle.

This same concept holds also for O_x and for NO_2; that is, reference measurement principles have been specified, and it is possible for several reference methods to exist for each of these pollutants. The NO_2 measurement principle and calibration procedure have not as yet been finalized; however, it is expected that the chemiluminescent measurement principle and associated calibration procedure will be specified by EPA in the near future to replace the Jacobs-Hochheiser reference method.

This concept does not apply for SO_2 and TSP, since the specified measurement techniques are manual methods consisting of a series of operations to be performed by an operator. The reference method is defined by this series of explicit manual operations, and thus there can be only one reference method.

Table 2 lists the reference methods or measurement principles specified by EPA for the NAAQS pollutants along with a brief description of the principle or method.

Methods other than those specified by EPA can be used for all NAAQS pollutants with the exception of TSP if equivalency to the reference method can be demonstrated. TSP is a special case since the pollutant is defined as the material collected by the high-volume sampler during the sample-collection phase of the reference method.

For SO_2, NO_2, O_x, and CO, both manual and continuous methods would be considered for equivalency. For manual methods, a consistent relation to a reference method must be shown, while continuous analyzers must demonstrate a consistent relation and meet performance specifications (Table 3).

The procedure that was established for determining reference and equivalent methods (*6*) also contains a provision for superseding or revoking reference methods and principles under certain conditions. As an example, it was found that problems existed with the reference method for NO_2

Table 1. National ambient air quality standards for major pollutants (*2*).

Pollutant	Description	Pollutant standard*	
		Primary†	Secondary‡
Total suspended particulates	Solid and liquid particles in the atmosphere, including dust, smoke, mists, fumes, and spray from many sources	75 μg/m³, annual geometric mean; 260 μg/m, maximum 24-hour average	60 μg/m³, annual geometric mean §; 150 μg/m³, maximum 24-hour average
Sulfur dioxide	Heavy, pungent, colorless gas formed from combustion of coal, oil, and other	80 μg/m³ (0.03 ppm), annual arithmetic mean; 365 μg/m³ (0.14 ppm), maximum 24-hour average	1300 μg/m³ (0.5 ppm), maximum 3-hour average
Carbon monoxide	Invisible, odorless gas formed from combustion of gasoline, coal, and other; largest man-made fraction comes from automobiles	10 mg/m³ (9 ppm), maximum 8-hour average; 40 mg/m³ (35 ppm), maximum 1-hour average	Same as primary
Photochemical oxidants (as O_3)	Pungent, colorless toxic gas; one component of photochemical smog	160 μg/m³ (0.08 ppm), maximum 1-hour average	Same as primary
Nitrogen dioxide	Brown, toxic gas formed from fuel combustion. Under certain conditions, it may be associated with ozone production	100 μg/m³ (0.05 ppm), annual arithmetic mean	Same as primary

* μg/m³, micrograms per cubic meter; mg/m³, milligrams per cubic meter; ppm, parts per million, the number of parts of a given substance in a million parts of air. †Primary, necessary to protect the public health. ‡Secondary, necessary to protect the public welfare. §Guide for assessing achievement of 24-hour secondary standard.

Table 2. Reference methods and measurement principles for NAAQS pollutants.

*Total suspended particulate—high-volume sampler (hi-vol)**

Air is drawn through a weighed glass-fiber filter for a known period of time. After being returned to the laboratory, the filter is conditioned at constant humidity and then reweighed. The difference in weights is the amount of particulate matter in the sampled air. This weight, divided by the known volume of air drawn through the filter, is the average particulate density and is normally expressed in micrograms per cubic meter of sampled air.

*Sulfur dioxide—pararosaniline**

Air is drawn through a sample of potassium tetrachloromercurate ($KHgCl_4$) solution, whereupon any SO_2 in the air is absorbed. The solution is returned to the laboratory, and formaldehyde and pararosaniline are added, forming a pink color. The intensity of this color, as measured by a colorimeter, is proportional to the SO_2 concentration in the sampled air.

Nitrogen dioxide—chemiluminescence†‡

This is a continuous instrumental method that draws in air over a heated catalytic converter to reduce any NO_2 to NO. The NO is reacted with ozone, generating light in proportion to the NO concentration. The original NO_2 concentration is obtained by substracting the concurrent NO concentration measured by the same technique in a parallel air sample that has not passed over the converter.

Carbon monoxide—nondispersive infrared spectrometry†

Air is passed continuously through a sample cell where some of the infrared radiation from a lamp is absorbed by the CO. The signal from this cell is compared with that from a reference cell. The ratio of these two signals is a measure of the CO concentration in the sampled air.

Photochemical oxidant—chemiluminescence‡

Air is drawn continuously through a sample cell simultaneously with ethylene gas. Any ozone in the air reacts immediately with the ethylene, thereupon emitting light. The amount of light emitted and measured by a photomultiplier tube is proportional to the ozone concentration in the sampled air.

*Reference method. †Measurement principle. ‡Proposed to replace Jacobs-Hochheiser method.

(that is, the Jacobs-Hochheiser bubbler method), in that the collection efficiency was somewhat dependent on the ambient concentration of NO_2. Also, NO interfered with the measurement process, causing higher concentration readings to be obtained than actually existed in the ambient air. The EPA revoked the method and is now in the final process of promulgating the chemiluminescent measurement principle as the replacement.

If a new principle or method that is clearly superior to the existing principle or reference method is developed, there are two approaches that can be taken. The analyzers that use this principle could be designated as an equivalent method or, if it was determined that the new analyzer method was substantially superior to the existing reference method, it would be designated as a replacement for the existing reference method or principle. However, both the benefits and the economic consequences on state and local agencies would be considered before designating a replacement method. Consequently, it is anticipated that supersession of reference methods will occur relatively infrequently and only when the advantages outweigh the disadvantages by a substantial margin.

Status of Air Quality Monitoring

Under provisions of the Clean Air Act, the states are given the responsibility for demonstrating attainment and maintenance of the NAAQS. For this purpose the states were required to establish air quality monitoring networks. The EPA prepared guidelines on the minimum amount of monitoring that should be performed by the states, based on the severity of existing pollution problems and on the population of the area to be monitored (*7*). The states were encouraged to install additional monitoring, above the minimum requirements, as their judgments dictated and their resources permitted. In their original implementation plans, many states proposed to do significantly more monitoring than the minimum required by EPA (*5*).

Table 4 presents a national summary of the total number of stations in the state networks for monitoring each of the five NAAQS pollutants. These networks, which were to be completed by 1974, were more than 80 percent complete by the end of 1974, as evidenced by data EPA has received for that calendar year. The total number of stations reporting any data during the year, the minimum EPA requirements that the states were to implement, and the percentage of the required networks completed by the states are shown (Table 4). Overall completion is less than 100 percent—even though the collective total of monitoring stations numbers nearly two-and-one-half times the minimum required stations—because several states have less than the minimum network size while many others are operating networks substantially larger than the minimum requirements. The numbers of stations proposed by the states in their implementation plans and their percent completion are also shown in Table 4. Where states have proposed networks larger than the minimum, these supersede the minimum and become their obligated networks. The unacceptable measurement methods (identified in Table 5) are not included in the totals of this table.

Table 5 identifies the number of stations monitoring each pollutant according to the method or principle being used. Most air monitoring is being conducted with reference methods or principles. These are the sole members of the "approved" category at present. Other methods that are not reference methods but are considered reasonable candidates for passing equivalency tests are listed as "unapproved." The last category, "unacceptable," includes those methods or measurement principles that are generally acknowledged to be inaccurate and obsolete.

Quality Assurance

In addition to acceptable instrumentation, other aspects of a monitoring program have a major impact on the resulting air quality measurements. These include: the location of the monitoring station; the location of the air inlet (probe) of the monitoring instrument at the station; the operation of the instrument, including quality control; as well as data handling, validation, and reporting. All of these considerations can be grouped under the broad topic of quality assurance. To assure data of acceptable quality for the intended purpose of the measurements, each element mentioned above must be considered. The following discussion focuses on each of these areas.

The location of the monitoring station is a major determinant in the air quality levels observed. Air quality is not only variable within most geographic areas, but the different air pollutants quite often have different patterns of variation over the same area; that is, SO_2 and CO levels can vary dramatically from one part of a city to another, but quite frequently the maximum concentrations are not found at the same place. Thus, if the objective of a monitoring station is to determine maximum population exposure in the city, the air monitoring instruments for different pollutants

Table 3. Summary of reference and equivalent methods.

Pollutant	Measurement principle or method	Reference method	Equivalent methods
TSP	High-volume sampler (manual method)	High-volume sampler	None possible
SO_2	Pararosaniline (manual method)	Pararosaniline	Manual or continuous
CO	Nondispersive infrared	*	Manual or continuous
O_3	Chemiluminescence	*	Manual or continuous
NO_2	Chemiluminescence	*	Manual or continuous

*None specified. Manufacturer must submit data documenting that the analyzer meets performance specifications.

Table 4. National summary of air monitors, 1974.

Pollutant	Total reporting*	*Federal Register* requirements	Percent completed†	SIP obligated	Percent completed†
TSP	3683	1341	92	3521	86
SO_2					
Continuous	503	213	64	698	50
Bubbler	1648	656	80	1434	80
CO	326	137	82	457	58
O_x	331	214	80	455	65
NO_2‡	1215	0		0	
Total§	6491	2561	85	6556	77

*Unacceptable methods not included. †Percentages are less than 100 because several states are below minimum network size, although others are operating networks larger than the minimum requirement. ‡The reference method has been withdrawn. Thus, there are technically no requirements until a new method is named. §NO_2 not included in totals.

would more than likely be placed at different locations. This is not to say that one could not locate all instruments at the same place and obtain useful information. For a different monitoring objective, such as determining trends in residential population exposure, instruments for measuring different pollutants could quite logically be put together at one location.

For some pollutants, such as CO, the location of the air inlet at the site is critical, since air quality measurements are highly dependent on distances from sources such as streets and intersections. For other pollutants, such as SO$_2$ and TSP, small minor sources nearby may exert undue influence on the measurement and result in unrepresentative air quality readings. Thus, influencing factors of this type must be considered in the probe placement to assure that valid, representative data are obtained. Several EPA studies provide additional information and guidance in locating air monitoring stations to fulfill the intended monitoring objectives (*8, 9*).

The operation, maintenance, and calibration of the monitoring instrument also have major impacts on the resulting air quality readings. Obviously, if the instrument is not operated according to the manufacturer's instructions, then the performance will not be satisfactory. Further, all mechanical and electronic devices need periodic maintenance in order to replace worn or defective parts. Finally, the calibration of the instrument with known standards is critical in obtaining accurate data. At several points in the operation and calibration process, it is also desirable to institute quality control check points. Examples and detailed information on how to conduct quality control programs have been published by EPA (*10*). Information on how to operate the instrument is normally provided by the manufacturer. The EPA has published procedures (*11*) for manufacturers to use in preparing operation manuals in order to standardize treatment and assure that all areas of concern are considered in the manual development.

The result of sampling with an air monitoring instrument, especially the continuous type, is normally a voluminous data set. Procedures must be established in the data handling, transcription, and reduction process to assure that the data are not altered in any way. In order for the data to be interpreted and used by decision-makers, it must be reported and presented in summary form. Various reports on ways to summarize and present air quality data are available (*12*).

Table 5. Pollutant method station summary, 1974.

Pollutant	Method or principle*	No. of stations	Percent of total	Approved	Unapproved	Unacceptable
TSP	High volume (FRM)*	3683	100	X		
CO	NDIR (FRM)	316	96	X		
	Coulometric	2	n†			X
	Flame ionization	10	4		X	
	Total	328				
SO$_2$	Colorimetric	122	6		X	
	Conductimetric	93	4		X	
	Coulometric	223	10		X	
	Flame photometric	59	3		X	
	Sequential conductimetric	6	n		X	
	Pararosaniline (FRM)	1648	77	X		
	Total	2151	100			
NO$_2$	Colorimetric	139	11		X	
	Coulometric	5	1		X	
	Chemiluminescence (FRM)‡	49	4	X‡		
	Saltzman bubbler	5	1			X
	Sodium arsenite (orifice)	294	24		X	
	Sodium arsenite (frit)	730	59		X	
	TEA				X	
	TGS				X	
	Total	1220	100			
O$_x$	Alkaline KI	10	3			X
	Coulometric	34	9		X	
	Neutral KI	71	19		X	
	Phenolphthalein	1	n			X
	Alkaline KI bubbler	18	5			X
	Ferrous oxidation	20	5			X
O$_3$	Chemiluminescence (FRM)	225	59	X		
	Coulometric	1	n		X	
	Ultraviolet				X	
	Total	380	100			

*FRM, Federal reference method or principle. †n = negligible. ‡Proposed measurement principle to replace Jacobs-Hochheiser procedure.

Air Pollution Monitoring and Data Analysis

Any discussion of data collection efforts should give some attention to the eventual uses of the data. This is particularly true in the case of air pollution monitoring, for which the measurements are not an end in themselves but rather are an essential input for research and decision-making problems. The fundamental goal of ambient air quality monitoring is to collect the information necessary for the protection of human health and welfare in accordance with the provisions of the Clean Air Act of 1970. While this is the driving force for EPA's monitoring efforts and regulations, it is convenient to define more specific monitoring objectives that are consistent with this overall goal and yet provide guidance on what types of information are needed. In addition to the monitoring of the criteria pollutants (TSP, CO, SO$_2$, photochemical oxidants, and NO$_2$), there are ongoing efforts concerned with other substances, which will allow us to identify potential hazards and improve our understanding of the complex interactions occurring in the ambient air. This is done by examining how the intended use of the data influences the type of monitoring information required and also how the interpretation of the data depends on detailed information about the monitoring site.

Although there is a variety of possible uses for air pollution data, there are two essential purposes when ambient standards are concerned: (i) determining compliance with legal standards and (ii) assessing trends or progress toward standards. These two factors, current status and future trends, are critical inputs in the decision-making process to ensure attainment and maintenance of ambient air which satisfies the legal standards designed to protect human health and welfare.

Even questions that seem relatively simple on a superficial basis may have several facets that affect the type of monitoring involved. For example, the NAAQS specifies upper limits for certain pollutants (*2*). These consist either of annual averages or a peak value that cannot be exceeded more than once per year. Therefore, to demonstrate compliance for a certain area, it might initially appear sufficient to place one monitor in the "worst" area and reason that if this site meets the standard, then so would all others. In practice, however, there may be little certainty as to where the "worst" site is. Moreover, a potential location that may monitor high short-term values may not be ideal in detecting high annual averages. Then there is the question of determining what action should be taken if an area is not in compliance. This could require information concerning the magnitude of the problem in terms of the amount by which the standard was exceeded, as well as the geographical extent of the problem. This kind of information is required in developing a control strategy and is an important concern in the design of a monitoring network.

The type of air quality standard also affects the type of monitor required. For example, national SO_2 standards specify limits on 3-hour, 24-hour, and annual averages. The local mixture of emission sources may determine which of these standards is the limiting one. Therefore, the choice of using a continuous instrument or a bubbler with an intermittent sampling schedule necessitates an understanding of which air quality standard is critical for the specified site. For example, in cases where the 3-hour standard is the controlling value, then the need for a continuous monitoring instrument would outweigh the cost advantages of a 24-hour bubbler. Similarly, the type of standard in question affects the general characteristics of the quality assurance program. When a once per year maximum value standard is the standard of concern, then the decision-making value will be the second highest value. The importance of this second highest data point necessitates a high degree of confidence in the overall quality of individual data points.

Interpretation of Monitoring Data

Once ambient measurements are collected, some type of data reduction is usually performed in order to conveniently summarize the available information. In this particular phase, it is quite easy for the ambient measurements to become hard values in themselves, totally divorced from any considerations of the monitoring site at which they were recorded. For example, CO measurements are clearly dependent on the distance from the monitor to the traffic flow (*13*). Therefore, if CO levels from several sites are compared to see which site is the "worst," it is essential to interpret the data in view of site placement. Efforts have been made to develop valid analysis techniques (*14*), but more work is needed to enable us to generalize about these results, which are gathered under less than uniform conditions.

In addition to the problem of site placement, there is the problem of modifications in the measurement technique. A change from one measurement principle to another may be recognized immediately and, therefore, not present too much of a problem. In some cases, however, the change may be more subtle and may not be clearly documented. Yet, what appears to be a slight modification to the measurement method may have dramatic consequences in the ambient concentrations recorded. For example, Mamane and Donagi (*15*) have discussed results indicating that a change from transparent to nontransparent sampling line tubing for SO_2 measurements reduced average values by a factor of almost 4, and even reversed the seasonal pattern.

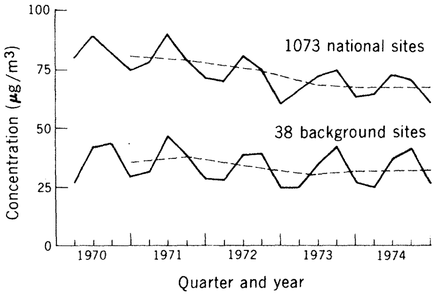

Fig. 1. Quarterly composite and yearly running averages for total suspended particulates for the nation.

Another case that has received attention occurred in Los Angeles in 1968 for CO, when changes were made in the calibration and a device was installed to remove sample moisture (*16*). As a consequence, the CO values measured after this time were markedly lower than previous measurements. It is also interesting to note that the apparent magnitude of such a shift can vary from one type of data summary to another; for example, in this case a frequency distribution shows a much sharper break than a presentation of annual averages.

From these examples, it is obvious that the interpretation of air quality data requires some consideration of the monitoring methodology involved. The examples also illustrate the need for careful documentation of any changes made in the monitoring methodology.

Example Analysis of National Trends

Although there are known limitations to much of the ambient data being collected, EPA must rely on such data to provide a national overview of the progress in achieving and maintaining clean air. A typical use of data would be an analysis of historical data to assess trends. In addition to the previously mentioned limitations, this type of analysis introduces two other complications: (i) the data base is shifting and (ii) those are not necessarily a random sample of the nation as a whole. Nevertheless, it is still useful to consider the national overview to obtain a general perspective of the progress made.

Figure 1 is a graphical presentation of national trends in annual mean TSP levels since 1970. It displays composite averages of quarterly means with a moving four-quarter average used for smoothing. The background sites are fairly stable, and the national trend is downward for the overall time period, with a certain degree of stabilization occurring in the past few years.

Any inferences from this type of graph require more information on the data base that was used. In this case, the data were obtained from NADB. In order to minimize the effect of a shifting data base, only sites having four consecutive quarters of data in 1970 or 1971 and also in 1972 to 1974 were employed. Although this approach avoids the problem of having a changing number of sites in each year as new monitoring sites begin operation, the historical data criterion does restrict the number of sites included in the analysis. To illustrate the expanding nature of the data base, if the above selection criteria were altered so that the two time periods were 1970 to 1972 and 1973 to 1974, the number of qualifying sites would increase by approximately 50 percent. Most of these sites, however, had little or no data in the 1970 to 1971 period and, therefore, this was not done in examining the 1970 to 1974 time period. The difference in number of sites for the two time criteria does serve to illustrate the progress that has been made in establishing monitoring networks.

Expansion of the data base is especially important with respect to point sources. Only 4 percent of the sites satisfying the historical data criterion were located near point sources. Thus, the national sample is primarily indicative of trends in urbanized areas. This is not surprising because the initial development of monitoring networks was concentrated on monitoring in the more densely populated areas. As monitoring networks expand, more information is becoming available for nonurban and suburban locations.

Conclusion

The Environmental Protection Agency has established National Ambient Air Quality Standards for five pollutants. Progress toward attainment of these standards is monitored by the states under EPA-approved State Implementation Plans. Data from state monitoring networks, which were approximately 80 percent complete in 1974, are routinely submitted to EPA. Various statistical summaries and analyses are performed and reported by EPA on a national scale, and the data are used for establishing control policies, priorities, and strategies.

To ensure valid, comparable data from the state monitoring networks, EPA has specified reference methods for NAAQS pollutants. Other candidate methods are currently being evaluated for equivalency to the reference methods. For the same purpose, EPA has published guidelines for quality assurance as related to air pollution monitoring. The guidelines cover such aspects as station location, instrument operation, and data handling, validation, and reporting.

Although there are known limitations to much of the ambient data currently being collected, EPA must rely on such data to provide a national overview of the progress in achieving and maintaining clean air. Dependable, reproducible instrumentation, backed by a nationwide quality assurance program are essential prerequisites to the compilation of an accurate composite picture of national air quality and to the equitable administration of control measures.

We have discussed only the major aspects of monitoring ambient concentrations of NAAQS pollutants in the low level atmospheric sector of the biosphere. Analogous programs exist for monitoring water quality, for monitoring emissions of air and water pollutants from their respective sources, for tracking the fate of toxic substances and radioactive materials, and for assessing the effects of noise. These programs differ widely in their scope and in the specific phenomena being measured, yet all share a common need for accurate, stable instrumentation.

References

1. Public Law 88-206, as amended by Public Law 91-604, 84 Stat. 1676 (42 U.S.C. 1857 *et seq.*).
2. Title 40—Protection of Environment, "National Primary and Secondary Ambient Air Quality Standards," *Fed. Register* **36** (84), 8186–8201 (30 April 1971).
3. *Aerometric and Emissions Reporting System* (internal report, U.S. Environmental Protection Agency, OAQPS, Research Triangle Park, N.C., February 1975).
4. *The National Air Monitoring Program: Air Quality and Emissions Trends Annual Report* (U.S. Environmental Protection Agency, Research Triangle Park, N.C., Publication EPA–450/1–73–001a, 1973); *Monitoring and Air Quality Trends Report, 1973* (U.S. Environmental Protection Agency, Research Triangle Park, N.C., Publication EPA–450/1–74–007, October 1974).
5. *Monitoring and Air Quality Trends Report, 1972* (U.S. Environmental Protection Agency, Research Triangle Park, N.C., Publication EPA–450/1–73–004, December 1973).
6. Title 40—Protection of Environment, "Ambient Air Monitoring Reference and Equivalent Methods," *Fed. Register* **40** (33), 7042 (18 February 1975).
7. Title 40—Protection of Environment, "Requirements for Preparation, Adoption, and Submittal of Implementation Plans," *ibid.* **36** (158), 15490 (14 August 1971).
8. *Guidance for Air Quality Monitoring Network Design and Instrument Siting* (U.S. Environmental Protection Agency, Research Triangle Park, N.C., OAQPS 1.2-012, January 1974).
9. F. L. Ludwig and J. H. Kealoha, *Selecting Sites for Carbon Monoxide Monitoring* (Stanford Research Institute, prepared under EPA contract 68–02–1471, July 1975).
10. *Guidelines for Development of Quality Assurance Program* (U.S. Environmental Protection Agency, Research Triangle Park, N.C., Publication EPA–R4–73–028a–e, 1975).
11. *Specifications for the Development of Instruction Manuals for Automatic Air Monitoring Instruments* (U.S. Environmental Protection Agency, Research Triangle Park, N.C., Publication No. EPA-450/3-74-038, December 1973); *Fully Proceduralized Instruction Manual for a Chemiluminescent Ozone Monitor* (U.S. Environmental Protection Agency, Research Triangle Park, N.C., Publication No. EPA–450/3–74–039, January 1974).
12. *Guidelines for Evaluation of Air Quality Trends* (U.S. Environmental Protection Agency, Research Triangle Park, N.C., OAQPS No. 1.2–014, February 1974); *Guidelines for the Evaluation of Air Quality Data* (U.S. Environmental Protection Agency, Research Triangle Park, N.C., OAQPS No. 1.2–015, February 1974); *Guidelines for Interpretation of Air Quality Standards* (U.S. Environmental Protection Agency, Research Triangle Park, N.C., OAQPS No. 1.2–008, August 1974); G. C. Tiao, G. E. P. Box, M. Groupe, S. T. Liu, S. Hillmer, W. S. Wei, W. J. Hamming, *Los Angeles Aerometric Ozone Data* (Department of Statistics, University of Wisconsin, Madison, Technical Report No. 346, 1973); G. C. Tiao, M. S. Phadke, M. Grupe, S. Hillmer, S. T. Liu, W. Fortney, *Los Angeles Aerometric Carbon Monoxide Data* (Department of Statistics, University of Wisconsin, Madison, Technical Report No. 377, 1974); M. S. Phadke, G. C. Tiao, M. Grupe, S. T. Liu, W. Fortney, S. Wu, *Los Angeles Aerometric Data on Oxides of Nitrogen 1957–1972* (Department of Statistics, University of Wisconsin, Madison, Technical Report No. 395, 1974).
13. W. Ott, *J. Air Pollut. Control Assoc.* **23**, 685 (1973).
14. D. C. Simeroth and G. Bemis, *Proc. Air Pollut. Control Assoc.*, in press
15. Y. Mamane and A. E. Donagi, *ibid.*, in press.
16. G. C. Tiao, G. E. P. Box, W. J. Hamming, "Analysis of the Los Angeles ambient carbon monoxide data" (Department of Statistics, University of Wisconsin, Madison, Technical Report No. 365, 1974, to appear in *J. Air Pollut. Control Assoc.*).

NEWS AND COMMENT

Nuclear War: Federation Disputes Academy on How Bad Effects Would Be

The National Academy of Sciences, the nation's leading source of scientific advice to the federal government, has issued a confusing and controversial report that it fears might encourage an opportunistic nation to assume it can safely trigger world war III.

The report—entitled *Long-Term Worldwide Effects of Multiple-Nuclear Weapons Detonations*—seemingly concludes that the impact of a nuclear holocaust on nations other than those hit directly by the detonations would not be so catastrophic as many had feared.

That finding was so alarming in its potential for encouraging bomb-happy military planners to let fly that Academy President Philip Handler felt obliged to write a letter of transmittal warning potential war-instigators that factors outside the scope of the Academy study rendered the results of a nuclear holocaust "entirely unpredictable."

But Handler's letter itself became controversial. The Federation of American Scientists, an activist group that counts half of America's living Nobel laureates among its members, issued a public denunciation that came very close to accusing the Academy of inadvertently encouraging war. The Federation charged that the Academy had reached a "false conclusion" (that the effects would be minimal). It also chided the Academy for focusing public attention on a "strangelovian scenario" (the notion that some nation might consider it advantageous to trigger world war III). Such public emphasis on a scenario that might arouse the "nuclear nuts" or a "monster nation" is "bizarre, unnecessary and possibly counterproductive," the Federation warned.

The U.S. Arms Control and Disarmament Agency, which had contracted for the $56,000 study, was also dismayed at the tone of the report. It rushed out statements asserting that information in the report actually demonstrates that no aggressor nation could launch a nuclear war without suffering devastating economic and ecological damage from the after-effects of the detonations.

That conclusion is not explicitly set forth anywhere in the Academy's report, its cover letter, or its accompanying press release. But 2 days after the report had been made public, Handler contacted *Science* to express anguish and concern that the Academy had failed to draw what he considered the most important lesson from the study's own data—namely, that the after-effects of a nuclear holocaust would be so devastating that there would be "no hiding place" for anyone. Unfortunately, he said, his letter, and the report itself, give the opposite impression.

Some press reports on the Academy's study emphasized the global damage apt to be caused by nuclear war, but others stressed that mankind would survive.

The report analyzed the likely effects that large-scale nuclear detonations in the Northern Hemisphere of 10,000 megatons (about half the total megatonnage in the arsenals of the superpowers) would have on nations that were not hit directly by the weapons. The focus was on effects that would remain evident as long as 30 years