Development of a New Reporting Technique for Air Quality

Reporting Air Quality Information

The U.S. Environmental Protection Agency (EPA) has long taken the lead in reporting air quality information to the general public. EPA routinely presents status and trends for the outdoor concentrations of different kinds of air pollutants in documents that provide clear and informative text, graphics, and data tables for general and technical audiences. These documents include the *National Air Quality and Emissions Trends Report* (the Trends Report) and a related booklet, *Latest Findings on National Air Quality: Status and Trends*. In addition, EPA maintains the Air Trends Web site (**http://www.epa.gov/airtrends/index.html**), which presents current and past air trends information and data, highlights of EPA's air pollution programs, and detailed information about air quality in the United States.

Air quality information is often complex and not always easily interpreted by the general public. As more and more information about air pollution and its effect on our health is being presented to the public through common channels such as television and radio news programs, daily newspapers, and Web postings, a need has arisen to provide the general public with a simple, visual method for assessing the degree of air pollution in their communities. As one approach to meeting this need, EPA is exploring a method of displaying air quality information that is designed to allow the general public to quickly and easily review the degree of air pollution in locations across the United States. Although this simplified display offers obvious benefits to users, there are limitations to this reporting technique as well. This paper describes the new reporting technique in detail and discusses its advantages and disadvantages.

A New Reporting Tool

EPA is evaluating the use of a new tool for displaying air quality information using data from EPA's Air Quality Index (AQI), which monitors air quality in selected city groupings known as metropolitan statistical areas (MSAs). Information for 319 MSAs would be included in the display. MSAs are defined by the Office of Management and Budget and generally include one or more entire counties, except in New England where cities and towns are the basic geographic units. MSAs have been selected as the reporting unit because they are the basis for AQI reports and for listings of attainment and nonattainment status for National Ambient Air Quality Standards (NAAQS).

The new display technique would present air quality information by MSA for the following pollutants:

- Carbon monoxide (CO)
- Nitrogen dioxide (NO_2)
- Ozone (O_3)
- Particulate matter (PM_{10} and $PM_{2.5}$)
- Sulfur dioxide (SO_2).

Information would be displayed using color-coded circles to indicate air quality for each of these pollutants in the selected MSAs. Users would be able to view the air quality status for different locations and pollutants by scrolling up and down an alphabetical list of MSAs.

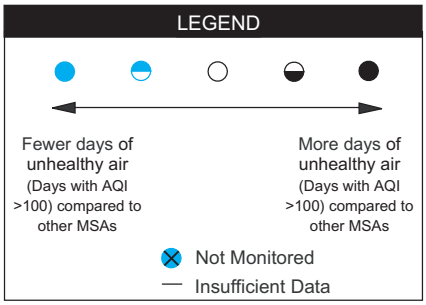
The purpose of this new reporting technique would be to provide a simplified, visual tool for interpreting air quality information in selected MSAs for a specific year for each of the selected pollutants. It would not be used as a rating system, nor would it show trends in air quality over time. Future versions of this method could allow users to sort the information based on the relative rankings for each pollutant of interest and generate a report based on their relative degree of suitability for someone with asthma, angina, or other health conditions.

Figure 1. Interpreting the symbols in the new display technique

Example MSA Report

Metropolitan Statistical Area (MSA)	Pollutants: O_3	CO	$PM_{2.5}$	PM_{10}	SO_2	NO_2
location 1	○	—	◓	●	●	●
location 2	●	●	◓	●	●	●
location 3	○	●	●	●	●	●
location 4	●	—	●	●	⊗	—
location 5	◒	●	●	●	●	●

Legend



Cutpoint Table for 2001

Pollutant	●	◓	○	◒	●
Ozone	1 or fewer days with AQI above 100	2 or 3 days with AQI above 100	4-12 days with AQI above 100	13-25 days with AQI above 100	more than 25 days with AQI above 100
Carbon monoxide	0 days with AQI above 100	1 days with AQI above 100	2 days with AQI above 100	3 days with AQI above 100	more than 3 days with AQI above 100
$PM_{2.5}$	1 or fewer days with AQI above 100	2 or 3 days with AQI above 100	4-12 days with AQI above 100	13-28 days with AQI above 100	more than 28 days with AQI above 100
PM_{10}	1 day with AQI above 100	2 days with AQI above 100	3-11 days with AQI above 100	12-36 days with AQI above 100	more than 36 days with AQI above 100
Sulfur dioxide	0 days with AQI above 100	1 day with AQI above 100	2 days with AQI above 100	3 days with AQI above 100	more than 3 days with AQI above 100
Nitrogen dioxide	0 days with AQI above 100	1 day with AQI above 100	2 days with AQI above 100	3 days with AQI above 100	more than 3 days with AQI above 100

Developing the Tool

Selecting Pollutants

The pollutants to be included in this display are CO, NO_2, O_3, particulate matter (PM_{10} and $PM_{2.5}$), and SO_2. These pollutants are five of the six "criteria" pollutants for which EPA has set National Ambient Air Quality Standards (NAAQS) as required by the Clean Air Act. The NAAQS for each pollutant indicate an outdoor (or ambient) concentration not to be exceeded on average over a 3-year period; concentrations below the NAAQS are preferable and would be expected to cause fewer adverse health effects. EPA tracks air quality based on measurements of pollutant concentrations in outdoor air at monitoring sites across the country and then compiles and processes these data to generate the Air Quality Index or AQI.

Designing the Display

Figure 1 shows one potential display method for a sample of several MSAs. In this sample, a solid black circle indicates poorer air quality than most MSAs and a solid blue circle indicates better air quality than most MSAs, with indications for three degrees of quality in between (half blue circle, empty circle, and half black circle). Again, this display would be pollutant-specific and limited to a specific year. It would not suggest air quality trends for these locations over time.

The colored circle symbols would be derived in different ways for different pollutants. For pollutants with a lot of data available, EPA would use percentiles to set ranges for the symbols. For those pollutants with few data, EPA would set the ranges to facilitate presentation.

Figure 1 presents the basis for the suggested symbols for each of the pollutants. The following section describes the methodology for assigning the symbols to data ranges in more detail.

Looking at sample MSAs in Figure 1, we can determine that location 3, for example, has fewer days of unhealthy air than most of the MSAs monitored for CO, particulate matter, SO_2, and NO_2 (indicated by the solid blue circles). For ozone, location 3 has about the median number of days of unhealthy air; in other words, roughly equal numbers of MSAs have more days and fewer days of unhealthy air than location 3 for ozone. Thus, location 3 would appear to be a relatively good location for someone with asthma, since particulate matter, sulfur dioxide, and ozone are pollutants of concern for people with asthma.

Where the "Not monitored" symbol (⊗) appears, no monitoring is performed for that pollutant in that particular MSA, and the MSA is presumed to have healthy air for that pollutant. The "Insufficient data" symbol (—) means that the area is monitored but not enough data were available to be included.

Methodology

The new reporting method would be developed from outdoor air quality data collected at monitoring stations operated by state, tribal, and local government agencies as well as some federal agencies, including EPA. The monitoring data are used to calculate the AQI, which reports daily air quality for a given location. The AQI values, in turn, would be the basis for this reporting tool. To generate the new display, three steps would be required, as described in the following sections: analyze outdoor air quality monitoring data, calculate the AQI, and assign the symbols shown in Figure 1 for each pollutant individually.

Analyze Outdoor Air Quality Data

As currently conceived, the display would be generated based on measurements of pollutant concentrations in the outdoor air at monitoring stations across the country. The air quality data consist of daily (24-hour) measurements for PM_{10} and $PM_{2.5}$ and continuous (1-hour) measurements for CO, NO_2, O_3, and SO_2.[1] The daily measurements for particulate matter are taken from monitoring instruments that produce one 24-hour measurement and typically operate on a systematic sampling schedule of once every 6 days, or 61 samples per year. In other words, these instruments generate one 24-hour sample every 6 days. EPA has determined that these 61 daily samples adequately represent outdoor air quality throughout the year. Monitoring instruments for CO, NO_2, O_3, and SO_2 operate continuously and produce a measurement every hour for a possible total of 8,760 hourly measurements in a year.

Calculate Air Quality Index

EPA compiles and processes outdoor air quality data to generate the AQI. The AQI is an index for reporting daily air quality for a given location and is a key tool in EPA's efforts to make air quality data accessible and useful to the general public. It indicates how clean or how polluted the outside air is. Based on monitoring data, the AQI gives a daily score of 1 to 500 for each pollutant monitored in each MSA. An AQI of 100 means the outdoor air concentration is generally no higher than the respective NAAQS. For example, an AQI of 50 means good air quality, whereas an AQI of 300 means poor air quality.

The AQI for particulate matter is a special case, in that day counts are derived slightly differently. AQI levels for particulate matter are best estimated from daily particulate matter monitors, and, therefore, the nation's air programs are installing more continuous particulate matter monitors. However, when using EPA's Federal Reference Method (FRM) data, the nondaily sampling schedules for particulate matter (e.g., one sample per 3 days) can affect the observed day counts. Therefore, EPA is evaluating methods for adjusting the counts for particulate matter days with an AQI over 100. The easiest method to adjust particulate matter counts, and that currently being used, is based on a simple ratio of the number of days in a quarter to the number of days with at least one sample in an MSA. The ratio is multiplied times the actual number of days in the quarter with the AQI above 100 for particulate matter to get an adjusted quarterly count, which can then be used to calculate an annual number. For example, if there are 90 days in a quarter and 15 sampling days in that quarter, the ratio of 90:15, or 6, is used to adjust the count of days with an AQI over 100 for particulate matter. Thus, if there are 2 days with sample values resulting in an AQI greater than 100, the count is adjusted to 12 days with an AQI greater than 100.

EPA maintains a Web site that fully explains the derivation of the AQI and its interpretation and use at **http://www.epa.gov/airnow/aqibroch/aqi.html#1**. This Web site includes information linking particular health effects such as asthma and angina to the different principal pollutants. Users can determine

which of the pollutants are particularly problematic for different health conditions. For example, asthma is related to concentrations of O_3, PM_{10}, $PM_{2.5}$, and SO_2, and angina is exacerbated by elevated concentrations of CO.

Assign Pollutant-Specific Symbols

To generate the new display, EPA would compile the AQI values for all MSAs (for a given time period, say calendar year 2001) and assign the symbols for each pollutant separately, as shown in Figure 1. For each pollutant, EPA would first count the number of days for each MSA when the AQI was above 100. The data for the MSAs would then be listed in order from the fewest days with AQI above 100 to the most days with AQI above 100. The data display technique is designed to indicate the MSA's relative rank by percentile. An MSA's percentile rank tells what portion of the sampled MSAs is above it (fewer days of unhealthy air) and what portion is below (more days of unhealthy air). For example, if an MSA is at the 90th percentile, 10% of the MSAs have fewer days of unhealthy air and 90% have more days of unhealthy air.

This approach works when there is sufficient variability, or range, in the data. In the 2001 data for O_3, PM_{10}, and $PM_{2.5}$, the range is relatively wide from the MSA with the fewest days with the AQI above 100 to the MSA with the most days, and the percentile method would be used for these pollutants. However, the 2001 data for CO, NO_2, and SO_2 do not vary enough among MSAs for percentiles to be derived. For these pollutants, the 2001 data show three or four MSAs having 1 day with the AQI greater than 100 and the remaining MSAs having no days with the AQI above 100. Therefore, the symbols would simply be assigned to 0, 1, 2, 3, 4, and greater than 4 days. While two different methods are used to set the boundaries, or "cutpoints," for the symbols, MSAs can be interpreted in the same manner for all pollutants.

The cutpoint table in Figure 1 presents the cutpoints, or ranges of day counts, indicated by each symbol for each pollutant. For pollutants with sufficient data variability to use the percentile method (i.e., O_3, PM_{10}, and $PM_{2.5}$), the top 5% would be considered to have the best air quality for that particular pollutant. Thus, MSAs within the top 5% would be given a blue circle. For example, as shown in Figure 1, location 4 has a blue circle for O_3, which means that location 4 is in the 5% of MSAs reporting the lowest number of days with the AQI above 100 for O_3. The remaining 95% of the MSAs sampled have more unhealthy days than location 4 with respect to O_3 levels (i.e., they had more days with the AQI for O_3 greater than 100). If there were 300 MSAs for which O_3 was sampled, location 4 would be one of 15 MSAs assigned a blue circle for O_3. Note that the blue circle does not indicate the actual number of days when the AQI was greater than 100; it simply tells whether location 4 experienced fewer or more unhealthy days than other sampled MSAs.

The remaining symbols for O_3, PM_{10}, and $PM_{2.5}$ would be assigned similarly, based on percentiles, as shown in the cutpoint table in Figure 1. A half blue circle would be assigned to MSAs above the 5th percentile and below the 25th percentile. An MSA with this symbol would have had more unhealthy days than those with a full blue circle (the top 5%), but fewer unhealthy days than the remaining 75% of the MSAs sampled. Likewise, the white circle would be assigned to MSAs from the 25th to 75th percentiles; they experience more unhealthy days than the MSAs with the full or half blue circles, but they have fewer unhealthy days than the remaining 25% of the MSAs sampled. The half black and full black circles would be assigned to the MSAs with more unhealthy days. The half black circle indicates that the MSA has more unhealthy days than 95% of the MSAs sampled and that only 5% of the MSAs have as many or more unhealthy days. The full black circle would be assigned to the MSAs with the most unhealthy days.

Assumptions and Limitations

The new reporting technique that EPA is evaluating includes several assumptions and limitations, as described below. These issues indicate areas where discussion and further development may be appropriate.

- The new display technique is based on the AQI, which, in turn, is based on short-term (daily) concentrations. However, for NO_2, PM, and SO_2, long-term standards also apply. Some MSAs may have no problem complying with short-term standards (thus being assigned a blue circle) while failing to meet the annual standard. An additional component that incorporates annual concentration data into the display technique may be desirable.
- At this time, the new display technique is designed to address CO, NO_2, O_3, particulate matter (PM_{10} and $PM_{2.5}$), and SO_2; it does not

address any hazardous air pollutants (HAPs). Addition of a component addressing HAPs could be considered. Benzene may provide a reasonable test case for reporting on HAPs, because it commonly occurs in ambient air and is monitored in the most locations.

- EPA acknowledges that the general public is not always familiar with MSAs. For example, users living in small towns may not realize they are part of an MSA named for a nearby larger town. Furthermore, not all areas in the country are in MSAs, and not all MSAs would be included in this display. Those MSAs with small populations, those with air quality that is so good that AQI reporting is not currently required, and those with too little monitoring data would not be included.
- Information would be presented for those air quality data that meet EPA's data quality requirements.[2] However, all pollutants are not monitored in all MSAs, and some MSAs are not monitored at all. For example, certain MSAs with small populations and those where the air quality is not considered a problem would not have data in the display. Thus, the "Not monitored" symbol can mean that there is no perceived air quality problem for that pollutant in that MSA, and the "Insufficient data" symbol means that there is not enough data available to be included. The latter case does not necessarily mean that there is no cause for concern.
- Different MSAs have different numbers of monitors. This display technique would not account for the fact that MSAs with more monitors will tend to have more days with AQIs above 100. The display technique might be modified to normalize the day counts based on number of monitors.
- Air quality may vary across a single MSA. In assigning a single symbol for each pollutant in each MSA, the display would not reflect this potential variation.
- The methods used to set the cutpoints for the data display are designed to give an intuitive visual display of air quality in MSAs. The new method would be based on percentiles to provide consistency in setting cutpoints from one year to the next; however, there are other approaches that might also work to meet the objectives.
- The color-coded symbols suggested for the new display technique would indicate an MSA's air quality relative to the air quality in the other MSAs reported. As such, the symbols would not be an indication of a particular level of health protection. Because the symbols would indicate relative air quality, a black circle, for example, could be assigned for few days or for many days of unhealthy air, depending on the number of unhealthy days for most MSAs. For example, a black circle would be assigned for 20 days of unhealthy air if most MSAs had fewer than 20 unhealthy days, or for 120 days of unhealthy air if most MSAs had up to 120 unhealthy days. It will be important to ensure that users are aware of the relative nature of the information.
- The color-coded symbols would be based on counts of days with the AQI exceeding 100, but, as currently conceived, there is no indication of the degree of exceedance. For example, a day with an AQI of 103 counts the same as a day with an AQI of 350. To reflect increased concern for days with higher AQI values, alternatives such as weighting days with an AQI above, say 200, could be considered.
- The display would present air quality for the current year. The percentile-based symbols would indicate an MSA's status relative to the other sampled MSAs. The percentiles reflect a given year's data; therefore, the number of unhealthy days implied by each symbol would change with each subsequent year's data. In its initial format, the display would not indicate trends in air quality or whether air quality in a particular MSA is improving or declining. Furthermore, users should be made aware that a single year's report may or may not indicate an MSA's general air quality or whether it is a "good" place to live, since any given year can reflect anomalies in air quality trends.
- The display would not provide any indication or distinction of source contribution.

Potential Uses for the New Display Technique

The new display technique is a work in progress. The preceding section described the report's current iteration, but EPA is exploring additional capabilities and features to enhance the technique. For example, EPA is determining how to add this display to the Air Trends Web site to allow users to sort and query the list to

focus on particular health effects. Capabilities currently being discussed for this new technique are described in the following sections.

Particular Health Effect Perspective

Allowing users to evaluate air quality with respect to particular health concerns is perhaps the most significant capability that is being considered for the new display technique. The AQI Web site (**http://www.epa.gov/airnow/aqibroch/aqi.html#1**) provides information linking health concerns and sensitive populations to particular pollutants and outdoor concentrations. For example, the AQI is used as the basis for advisories to people with asthma; these individuals are advised to limit outdoor exertion when AQI values for O_3, PM_{10}, $PM_{2.5}$, or SO_2 are over 100. Similarly, people with angina are cautioned when the AQI for CO is over 100. EPA is looking into ways in which the MSA report could allow users to sort the data based on specific health-based concerns for any of these pollutants and generate a report focusing on health concerns for someone with asthma, angina, or other health conditions.

Visibility and Regional Haze

Degradation in visibility is related to several criteria pollutants and is an important environmental issue for the public, particularly in National Parks and wilderness areas (Class I areas). For example, the annual Trends Report presents useful information on the impacts of air pollution on visibility. Without the effects of pollution, a natural visual range in the United States is approximately 75 to 150 km (45 to 90 miles) in the East and 200 to 300 km (120 to 180 miles) in the West. However, data collected by EPA show that, in 1999, mean visual range in the East was only 24 km (14.4 miles) for the worst days and only 84 km (50.4 miles) for the best days. In the West, the mean visual range for 1999 was 80 km (48 miles). EPA is considering methods for including similar graphical information of this type of data in the display.

Multiyear Reports

EPA is considering adding a multiyear dimension to the display. In addition to presenting the annual reports described above, EPA would also provide graphically similar reports that would reflect a 5- or 10-year average for the number of days that the AQI was above 100 for each pollutant in each MSA. Using these averaged day counts, percentiles would be derived and symbols assigned as described above for the annual data. Users could see the report for a 5-year average as well as for any individual year for the past 5 years. Reports for individual years could be compared to the average as well as to each other.

Summary and Conclusions

This display technique would provide the general public with a new tool to review air quality in MSAs around the United States. The primary function of the display would be to present location- and pollutant-specific air quality data in a graphical format that allows for easy interpretation of air quality data for MSAs. The display would not provide new or additional air quality data; rather, it would present existing data in a new format. The graphical display of data would improve the public's access to air quality information and enhance their ability to use this information in a meaningful way. Potential capabilities that may be added include a Web-based application that would allow users to sort and query information to generate customized reports, as well as visibility and multiyear components.

EPA recognizes that there are limitations to this new display technique and is continuing to assess the usefulness of such a reporting method as well as additional capabilities that might be added. Developing a simple metric for displaying air quality data on an urban basis across the nation is a difficult and challenging endeavor. However, EPA feels that this information is useful and informative to the public, especially to those who have potential health concerns related to poor air quality. A graphical display that is easily understood is essential to communicating this information, and EPA will continue to refine the display to ensure that it meets this objective based on comments and input from the air quality community and potential users.

References

1. Although continuous PM monitors are being installed and some continuous monitoring data are available, these data would not be included in this display. Only Federal Reference Method (FRM) data would be incorporated into the data display as currently conceived, and the PM continuous monitoring data are not based on EPA's FRM.

2. For more information on EPA's data quality requirements, see Appendix B–Metropolitan Area Trends of the Trends Report at **http://www.epa.gov/airtrends/metro.html**.