Indicator: Ambient Concentrations of Nitrogen Dioxide (355)

Nitrogen dioxide is a reddish-brown, highly reactive gas that is formed in the ambient air through the oxidation of nitric oxide (NO). Nitrogen oxides (NOx), the term used to describe the sum of NO, NO_2, and other oxides of nitrogen, play a major role in the formation of ozone in the atmosphere through a complex series of reactions with VOCs. A variety of NOx compounds and their transformation products occur both naturally and as a result of human activities. Nitrogen dioxide is the most widespread and commonly found nitrogen oxide (EPA, 2003).

Short-term exposures (e.g., less than 3 hours) to low-levels of NO2 may lead to changes in airway responsiveness and lung function in individuals with preexisting respiratory illnesses. These exposures may also increase respiratory illnesses in children. Long-term exposures to NO2 may lead to increased susceptibility to respiratory infection and may cause irreversible alterations in lung structure. (EPA, 1995).

Atmospheric transformation of NOx can lead to the formation of ozone and nitrogen-bearing particles (e.g., nitrates and nitric acid). Nitrogen oxides contribute to a wide range of effects on public welfare and the environment, including global warming and stratospheric ozone depletion. Deposition of nitrogen can also lead to fertilization, eutrophication, or acidification of terrestrial, wetland, and aquatic (e.g., fresh water bodies, estuaries, and coastal water) systems. These effects can alter competition between existing species, leading to changes in the number and type of species (composition) within a community. For example, eutrophic conditions in aquatic systems can produce explosive algae growth leading to a depletion of oxygen in the water and/or an increase in levels of toxins harmful to fish and other aquatic life (Air Quality Criteria for Oxides of Nitrogen, EPA 600-8-91-049aF-cF, 1993).

This indicator reflects ambient concentrations in parts per million (ppm) of NO_2 from 1980 to 2004, based on the annual arithmetic average. This indicator displays trends averaged over 91 sites that have consistent data for the period of record in the National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS) network and other special purpose monitors.

What the Data Show

(Note: discussion of annual median concentrations will be added to this section)

Figure 355-1 shows that the national annual mean NO_2 concentration in 2004 was 37 percent lower than that recorded in 1980. The highest annual mean NO_2 concentrations are typically found in urban areas.

Consistent with the nationwide trend, NO_2 levels in all ten regions have steadily decreased since 1980, with net reductions over this time ranging from 25% to 44% (Figure 355-2).

Figures 355-1 and 355-2 also show the 90th and 10th percentiles of NO_2 concentration based on the distribution of annual statistics at the monitoring sites. Thus, the graphics display for each year, the concentration range where 80 percent of measured values occurred.

Indicator Limitations

- Because ambient monitoring for NO_2 occurs almost exclusively in urban high traffic areas, the average concentrations presented in this indicator likely do not reflect NO_2 levels in rural areas.
- In rural and remote areas, air mass aging could foster greater relative levels of peroxyacetyl nitrate (PAN) and nitric acid. These compounds interfere with the measurement of NO_2. Consequently, concentrations of NO_2 in rural and remote areas may be overestimated.

Data Sources

US EPA Air Quality System (http://www.epa.gov/air/data/index.html).

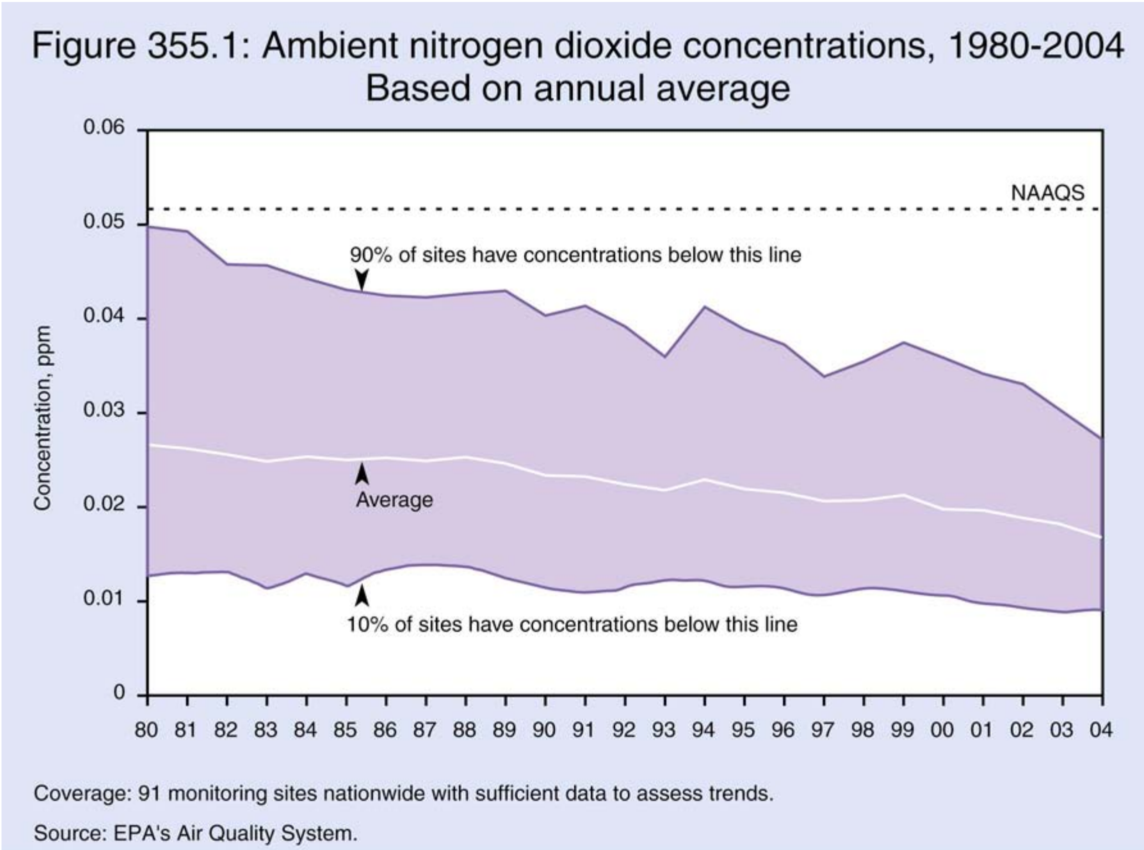
References

U.S. Environmental Protection Agency. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC; U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

U.S. Environmental Protection Agency. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003.

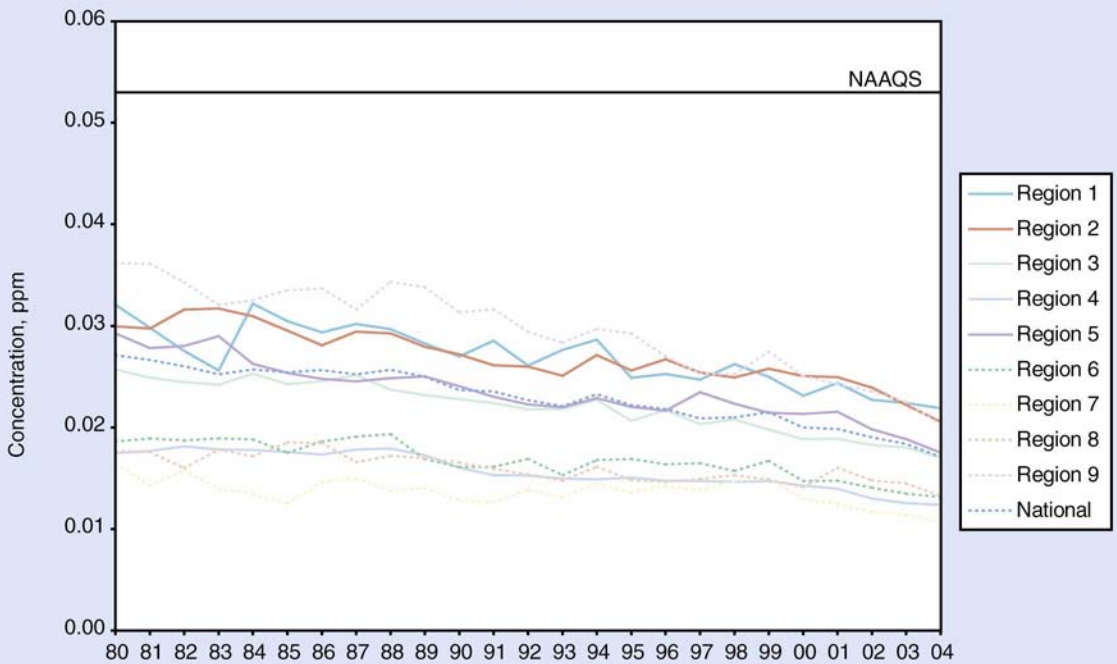
U.S. Environmental Protection Agency. Review of the National Ambient Air Quality Standards for Nitrogen Oxides: Assessment of Scientific and Technical Information, EPA-452/R-95-005. Research Triangle Park, NC; U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, September 1995.

Graphics



A trend line with median concentrations will be added to this graph after the data points are generated.

Figure 355.2: Trends in nitrogen dioxide levels, 1980-2004, by EPA region
Based on annual average concentrations



Source: EPA's Air Quality System.

Note: The figure does not include data for Region 10, because an insufficient number of monitoring sites were available to estimate a trend.

R.O.E. Indicator QA/QC

Data Set Name: AMBIENT NO2 CONCENTRATIONS
Indicator Number: 355 (138764)
Data Set Source:
Data Collection Date:
Data Collection Frequency:
Data Set Description: Ambient NO2 Concentrations
Primary ROE Question: What are the trends in outdoor air quality and their effects on human health and the environment?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The ambient air quality data presented are based on data retrieved from the Air Quality System (AQS) in Sept. 2005. These are direct measurements of pollutant concentrations at monitoring stations operated by tribes and state and local governments throughout the nation. The monitoring stations are generally located in larger urban areas. EPA and other federal agencies also operate some air quality monitoring sites on a temporary basis as a part of air pollution research studies. The national monitoring network conforms to uniform criteria for monitor siting, instrumentation, and quality assurance. The program under which the data are collected is the NAMS/SLAMS network. A description of this network includes: 1) 40 CFR 50 - National ambient air quality standards (NAAQS) and reference methods for determining criteria air pollutant concentrations in the atmosphere; 2) 40 CFR 53 - Process for determining reference or equivalent methods for determining criteria air pollutant concentrations in the atmosphere; 3) 40 CFR 58 - Ambient air quality surveillance (monitoring) requirements. These results have been peer reviewed. The most recent review was as a part of the National Air Quality and Emissions Trends Report, 2001 EPA 454/K-02-001, September 2002. This report is available at: http://www.epa.gov/airtrends.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. In 2004, thousands of monitoring sites reported air quality data for one or more of the six National Ambient Air Quality Standards (NAAQS) pollutants to AQS. The sites consist of National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS), and other special-purpose monitors. NAMS were established to ensure a long-term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent database for air quality comparisons and trends analysis. SLAMS allow state or local governments to develop networks tailored for their immediate monitoring needs. The monitoring objectives for the NAMS/SLAMS network are found in: 1) 40 CFR 58, Appendix D, http://www.epa.gov/ttn/amtic/; 2) 40 CFR

58.2(c); 3) EPA 454/R-98-004, Part I, Section 3.2, http://www.epa.gov/ttn/amtic/cpreldoc.html.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The conceptual model used to derive these indicators has been used and thoroughly reviewed as part of the Agency's national report on air quality trends for 25 years. The model has three basic elements: 1) Determine if year is valid for inclusion. Must have greater than or equal to 3285 valid hours of measurements to meet the annual trends data completeness requirement. 2) Determine if site is valid for trends. Must have greater than or equal to 75% of possible years in the time series. For the 25-year period 1980-2004, trend sites must have at least 19 valid years and must not be missing more than 2 consecutive years of data. 3) Interpolate for missing years. Simple linear interpolation is used to fill in for missing years in the following way. Missing annual summary statistics for the in-between years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates. References include: U.S. Environmental Protection Agency. The Ozone Report - Measuring Progress through 2003, EPA 454/K-04-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, April 2004. Latest Findings on National Air Quality - 2002 Status and Trends, 2003, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The data for these indicators are collected under a single national program of ambient air quality surveillance known as the National Air Monitoring Stations (NAMS)/State or Local Air Monitoring Stations (SLAMS) network. The NAMS/SLAMS network focus is on providing data for assessing public health consequences of criteria pollutants and, therefore, the monitors tend to be concentrated in urban areas that have the highest population density, with modest coverage in most rural areas. Pollutant specific guidance for establishing NAMS/SLAMS networks is provided in 40 CFR 58, Appendix D.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The network is not focused on sensitive populations like children, the elderly, asthmatics, etc., but samples them in proportion to their occurrence in the general populations of the areas monitored.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes, the level of the corresponding national ambient air quality standard (NAAQS) is 0.053 ppm. This level is indicative of the state of the environment with respect to ambient air concentrations of nitrogen dioxide.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Standard data documentation is available to support these data and can be accessed at: 1) General Air Quality and National Monitoring Network (http://www.epa.gov/ttn/amtic/moninfo.html); 2) National Air Quality and Emissions Trends Report, 2003 Special Studies Edition (http://www.epa.gov/air/airtrends/aqtrnd03/).

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. The data used to develop these indicators are available through the Air Quality Subsystem of the Aerometric Information Retrieval System (AIRS). Information on AIRS can be obtained at: http://www.epa.gov/ttn/airs/. In addition, data from AIRS can be accessed via the Internet at: http://www.epa.gov/air/data/index.html.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The Ambient Monitoring Technology Information Center (AMTIC) contains information and files on ambient air quality monitoring programs, details on monitoring methods, relevant documents and articles, information on air quality trends and nonattainment areas, and federal regulations related to ambient air quality monitoring. This information can be found in Section 3, EPA - TTN - AMTIC National Air Monitoring Strategy: http://www.epa.gov/ttnamti1/monstratdoc.html.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The QA/QC of the national air monitoring program has several major components: the Data Quality Objective (DQO) process, reference and equivalent methods program, EPA's National Performance Audit Program (NPAP), system audits, and network reviews (Available on the Internet: www.epa.gov/ttn/amtic/npaplist.html). To ensure quality data, the SLAMS are required to meet the following: 1) each site must meet network design and site criteria; 2) each site must provide adequate QA assessment, control, and corrective action functions according to minimum program requirements; 3) all sampling methods and equipment must meet EPA reference or equivalent requirements; 4) acceptable data validation and record keeping procedures must be followed; and 5) data from SLAMS must be summarized and reported annually to EPA. Finally, there are system audits that regularly review the overall air quality data collection activity for any needed changes or corrections. Further information available on the Internet (http://www.epa.gov/cludygxb/programs/namslam.html) and through United States EPA's Quality Assurance Handbook (EPA-454/R-98-004 Section 15). There is a Quality Assurance Project Plan from each state or local agency operating a NAMS/SLAMS monitor meeting the AEPA Requirements for Quality Assurance Project Plans, EPA QA/R-5. The quality assurance plans for specific sites are publicly available by request to the reporting agency or the corresponding EPA Regional Office. The plans are audited at least once every three years as required in 40 CFR 58, Appendix A, Section 2.5. In addition, the data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The air quality statistics presented relate to the pollutant specific NAAQS and comply with the recommendations of the Intra-Agency Task Force on Air Quality Indicators. A composite average of each trend statistic is used in the graphical presentations. All sites were weighted equally in calculating the composite average trend statistic. Missing annual summary statistics for the second through ninth years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. The data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. We are not aware of any sources of error that may affect the findings developed from these data.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The national air monitoring network for the six criteria air pollutants is extensive; however, there are far more monitors in urban areas than in rural areas. Monitoring in urban areas helps to characterize population exposures, because population tends to be concentrated in urban areas. More rural monitoring might help scientists assess transport and ecological effects, although EPA uses additional tools and techniques (e.g., models and spatial analyses) to augment limited monitoring in some areas and to better characterize pressures on ecological condition. EPA is currently conducting a national assessment of the existing ambient monitoring networks and is analyzing, among other issues, the need for and appropriateness of each of the nation's urban monitors. Atmospheric concentrations of NO2 are determined by indirect photomultiplier measurement of the luminescence produced by a critical reaction of NO with ozone. The measurement of NO2 is based first on the conversion of NO2 to NO, and then subsequent detection of NO using this well-characterized chemiluminescence technique. This conversion is not specific for NO2, hence chemiluminescence analyzers are subject to interferences produced by response to other nitrogen-containing compounds (e.g., peroxyacetyl nitrate [PAN]) that can be converted to NO. The chemiluminescence technique has been reported to overestimate NO2 due to these interferences. This is not an issue for compliance because there are no violations of the NO2 NAAQS. In addition, the interferences are believed to be relatively small in urban areas. The national and regional air quality trends depicted are based primarily on data from monitoring sites in urban locations and are expected to be reasonable representations of urban NO2 trends. That is not the case in rural and remote areas, however, where air mass aging could foster greater relative levels of PAN and nitric acid and interfere significantly with the interpretation of NO2 monitoring data.