Indicator: Ambient Concentrations of Manganese Compounds (200R)

Manganese is a naturally occurring metal that is ubiquitous in the environment. Exposure to low levels of manganese in the diet is considered to be nutritionally essential for people and animals (ATSDR, 1997). However, exposures to elevated concentrations of manganese are harmful to human health and have been associated with subtle neurological effects, such as slowed eye-hand coordination. The Reference Concentration (RfC) for manganese is 0.05 micrograms per cubic meter (ug/m^3) based on impairment of neurobehavioral function in people. The RfC is an estimate of a chronic inhalation exposure that is likely to be without appreciable risk of adverse non-cancer effects during a lifetime. At exposures increasingly greater than the RfC, the potential for harmful effects increases (ATSDR, 1997 and USEPA, 1999).

Manganese compounds are emitted by iron and steel production plants, power plants, coke ovens, and many smaller metal processing facilities. In addition to these stationary sources, manganese may also be contributed in border communities by vehicles using Canadian fuel with the additive methylcyclopentadienyl manganese tricarbonyl (MMT). Although manganese compounds are air pollutants of concern nationwide, they are of special concern in Region 5. The 1999 National Emissions Inventory showed that Region 5 had the highest manganese emissions of all EPA Regions, contributing 36.6% of all manganese compounds emitted nation-wide (NEI, 1999). The Risk Screening Environmental Indicators (RSEI) tool was developed by the Office of Pollution Prevention and Toxics to model the human health related risk from multi-media exposures to over 400 Toxic Release Inventory (TRI) hazardous compounds. Based on multimedia exposure, the RSEI tool identified manganese compounds in Region 5 as the #1 risk priority based on 1998 and 1999 TRI emissions data, and identified as the #2 priority risk based on 2000, 2001, and 2002 TRI emissions data.

This indicator presents ambient concentrations of manganese compounds measured as total suspended particulates (TSP) by direct monitoring. The data are from 53 locations in the Region that had a complete year of data reported to the Air Quality System (AQS) national database in 2004. Average annual manganese concentrations were calculated for each monitoring site. A concentration trend was determined using a subset of 21 monitoring sites that had four or more complete years of data between 2000 and 2004. As annual average concentrations are representative of long-term inhalation exposures, the ambient monitoring data are displayed in comparison with the manganese RfC.

Monitor locations were divided into different categories based on land use as defined in AQS: commercial and mobile, industrial, residential, and agricultural and forest. The land use category is only somewhat indicative of the area represented by an ambient air monitor. For example, a site categorized as "industrial" may adjoin a densely populated community where many residents are exposed to ambient pollution. U.S. Census data were consulted to determine the population density within a ½-mile radius of each monitoring site, measured as persons per square mile (sq. mi.). Census data for the year 2000 were accessed via EPA's Environmental Justice Geographic Assessment Tool (USEPA, 2005). The Census defines a population density greater than 1,000 persons per sq. mi. as "urbanized". A density over 5,000 persons per sq. mi. is commonly termed "highly urbanized".

What the Data Show

In 2004 average annual ambient concentrations of manganese ranged from 0.006 to 2.126 ug/m^3 at the 53 monitoring stations in the Region. The median concentrations of site annual averages by land use are as follows (Figure 200R-1): commercial and mobile (0.036 ug/m^3), industrial (0.049 ug/m^3), residential (0.035 ug/m^3), and agricultural and forest (0.020 ug/m^3). Eighteen sites had an average manganese concentration higher than the RfC; 10 of these sites are categorized as industrial, 4 commercial or mobile, and 4 residential. The average population densities within a ½-mile radius of these sites were as follows:

commercial and mobile (5,706 per sq. mi.), industrial (2,916 per sq. mi.), residential (5,107 per sq. mi.), agricultural and forest (50 per sq. mi.).

The median concentration of 21 trend sites showed a 14.7% decline in ambient manganese between 2000 and 2004 (Figure 200R-2). Despite this decline, the median concentration for these sites remained nearly equal to the RfC. These sites had the following land use designations: commercial and mobile (6 sites), industrial (9 sites), residential (6 sites), agricultural and forest (no sites).

Indicator Limitations

- AQS data represent several sites per State, but do not have full geographic or temporal coverage. Some emissions "hotspots" are included, while others may exist that have not been monitored.

Data Sources

Ambient air data as reported to the Air Quality System (AQS) database, EPA Office of Air and Radiation, is available at the following URL: http://www.epa.gov/air/data/aqsdb.html

References

Agency for Toxic Substances and Disease Registry (ATSDR). *Toxicological Profile for Manganese (Update).* Draft for Public Comment. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 1997.

U.S. Environmental Protection Agency. *Integrated Risk Information System (IRIS) on Manganese*. National Center for Environmental Assessment, Office of Research and Development, Washington, DC. 1999.

U.S. Environmental Protection Agency. National Emissions Inventory (NEI) website, 1999, Query Link accessed by: www.epa.gov/air/data, August 2005.

U.S. Environmental Protection Agency. Environmental Justice Geographic Assessment Tool (EnviroMapper). Website updated March 2005, accessible at: http://www.epa.gov/enviro/ej/

Graphics

Figure 200R.1: Ambient manganese as TSP, Region 5 annual average concentrations, 2004

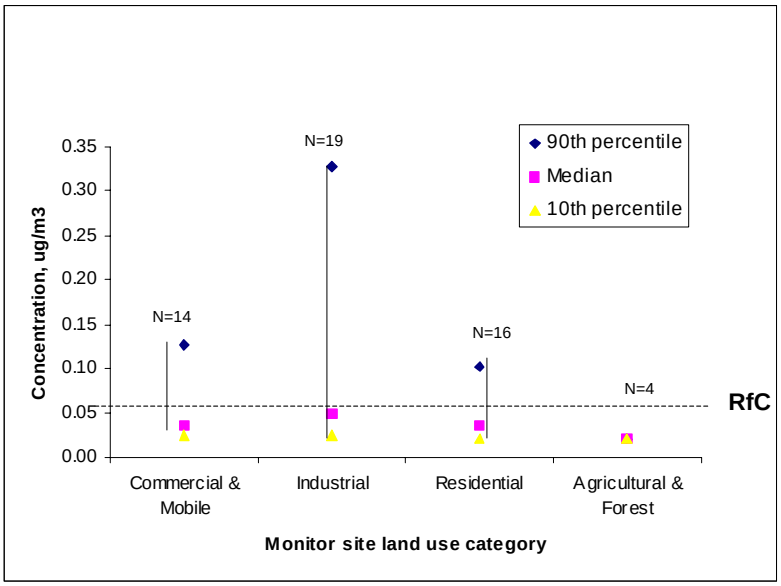
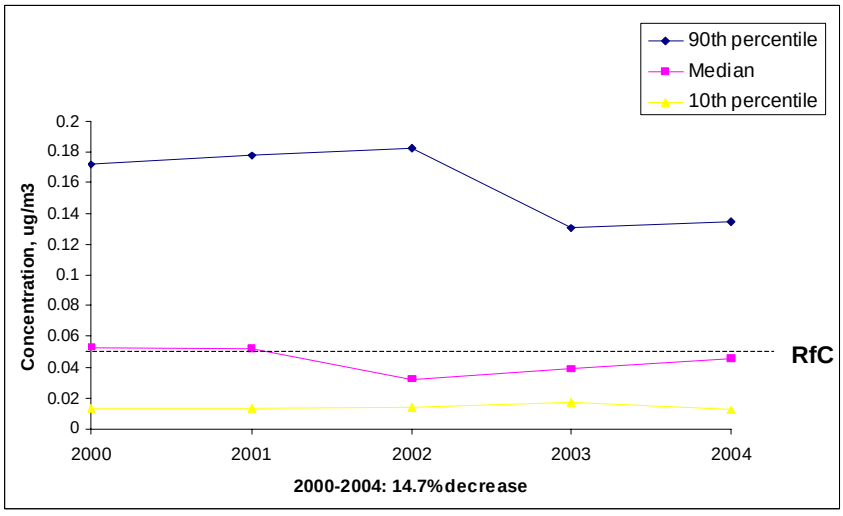


Figure 200R.2: Ambient manganese as TSP, annual average concentrations, Region 5, 2000-2004



Coverage: 21 monitoring sites with sufficient data to assess trends

R.O.E. Indicator QA/QC

Data Set Name: AMBIENT CONCENTRATIONS OF MANGANESE COMPOUNDS
Indicator Number: 200R (89159)
Data Set Source: AQS monitoring
Data Collection Date: AQS 1994 through 2003
Data Collection Frequency: AQS frequency varies
Data Set Description: Ambient Concentrations of Manganese Compounds
Primary ROE Question: What are the trends in outdoor air quality and their effects on human health and the environment?
Comment: NATA modeling results and the AQS monitoring database provide complementary views of the ambient manganese (Mn) condition in Region 5. NATA modeling is based on 1999 emissions inventories compiled by State agencies. This national dataset provides national coverage. However the model outputs are averaged across each county, so local hotspots are "smoothed" out. AQS monitoring data is spotty in terms of geographic coverage and temporal coverage. The data are valuable, however, because they identify multiple local hotspots which have been smoothed by NATA results. Taking the two data sources together, the reader may see elevated Mn in some counties (according to NATA) and may see localized areas within the county that have even higher concentrations (according to AQS). Even if AQS data were not collected in the high Mn NATA counties, the reader may expect that hotspots exist in the county. AQS data are adequate to calculate multi-year trends at sites with more than 4 years of data. NATA results for 1999 emissions will be comparable to 2002 outputs to be developed in the future.

Question/Response

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

AQS monitoring data are reported by State and Local agencies and industrial firms, following standard EPA metholologies and under approved QAPPs. Manganese data are collected as total suspended particulates (TSP) and samples analyzed according to EPA (IO) methods. http://www.epa.gov/air/data/aqsdb.html and http://www.epa.gov/ttn/atw/nata/natsaov.html

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

AQS data are generated following standard EPA methods and approved workplans, specific to the State or Local agency involved. The Region 5 assessment includes only AQS data from sites that are sufficient in quantity to produce valid annual averages. At a minimum, sites had 80% data completion for 3 seasonal quarters on a 1-in-12 day sampling schedule, i.e. at least 18 measurements per year.

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?

Given adequate data completeness, ambient air monitoring data is widely used by EPA to generate annual average concentrations for individual or aggregated sites. Multi-year trends are typically calculated as a linear regression of log-transformed annual averages against year. Statistical significance of the resulting trend coefficient is determined using a t-test with 95% confidence. The trend coefficient is then converted to an annual percent change per year.

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

AQS does not provide full geographic coverage, although most larger urban areas in the Region had one or more sites. AQS sites were included only if data at existing sites were adequate to generate a valid annual average concentration for one or more years. Some sites operated during the entire 10-year period of 1994-2003, but most collected less than 5 years of data. Multi-year trends were determined for sites with 4 or more years of valid data.

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

AQS sites were generally selected to represent specific community exposures, including local industrial hotspots and other sites in typical urban communities. Few of the sites are "background". They are all populated areas which vary in that some are near industrial fencelines while others represent more city-wide levels. Census data indicate that each site has hundreds or thousands of residents within 1/2 mile. Sensitive populations are included in many of these urban communities.

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

IRIS RfC is an established benchmark to indicate whether ambient Mn concentrations are of concern, although the RfC is not used explictly in this indicator. Ambient concentrations are also typically compared to measurements collected at other urban and rural sites nationally.

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

Details of AQS sampling procedures are available within the AQS database. AQS contains, for each monitoring site, the specific sampling and analytical methods used by the collecting agency and other information.

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?

AQS data are all fully public and available. Access to the database is limited to those with an AQS account and appropriate software, however. Summary data are accessible to the public at the AirData website: www.epa.gov/air/data/index.html Non-AQS users may obtain raw data by request (FOIA or informal) from EPA by submitting a data request to: www.epa.gov/ttn/airs/airsaqs/detaildata/datarequest.html contacting Virginia Ambrose 919-541-5454

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

AQS data is collected following standard procedures. Assumptions and methods used for data summary are easily reproducible.

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

AQS data is reported by various agencies, each of which have approved workplans and QAPPs. Copies of some QAPPs are housed at EPA Region 5, others could be obtained from the respective local agency upon request. R5 air monitoring QA officer, Gordon Jones, can provide further detail about QAPPs approved for State and Local agencies.

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)?

AQS data were summarized by Region 5 following consistent and simple assumptions. Incomplete datasets were not considered. For complete annual datasets, simple mathematical averages were calculated per year. AQS data represent specific points on the map and are not used to interpolate conditions between sites.

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

AQS site averages are based on years of data with sufficient measurement quantity. Specifically, 80% data completion on a 1-in-12-day sampling schedule is required to compile a valid quarter of data; 3 valid quarters are required to comprise a valid year of data. Confidence intervals could potentially be calculated around the data averages; this should not be necessary, however, because data are restricted to sites with complete years of data.

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

No, AQS data used here are sufficient to demonstate that some communities have higher concentrations than others. The statistical test for temporal trends is robust (t-test at 95% confidence) and unlikely to confirm existence of a data trend where one does not exist.

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?

AQS monitoring sites are spotty in geographic and temporal coverage. The absence of data in an area should not be inferred to mean that there are no elevated Mn concentrations.